CHEMICAL & METALLURGICAL ENGINEERING

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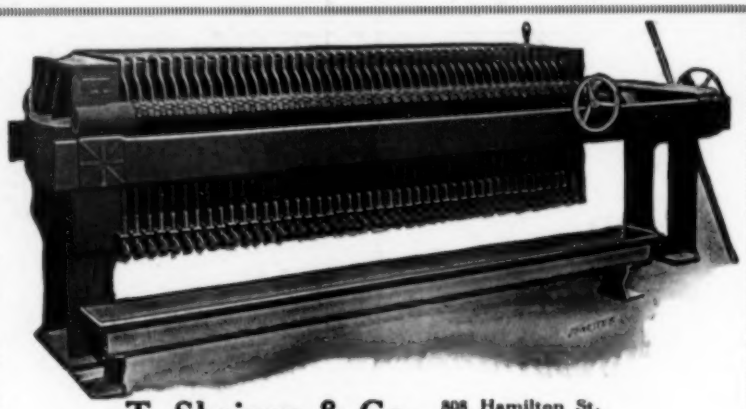

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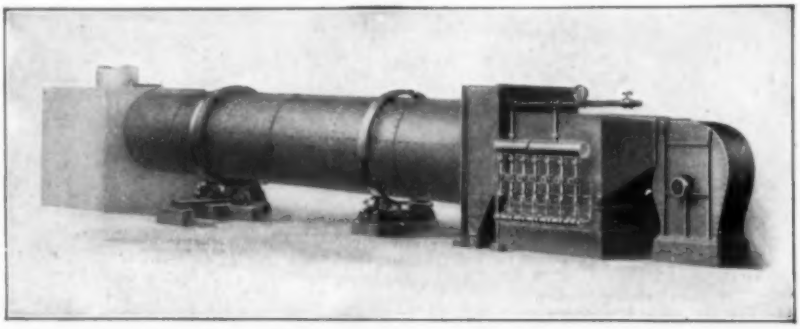

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Contents for November 1, 1918

Volume 19, *Number* 9

EDITORIALS

Steel Conditions After the War....649
Help for the Gold Producer....650
Inscrutable in the Ultimate....650
The Development of Water Softening....651

READERS' VIEWS AND COMMENTS

Consumption and Conservation of Tin. By *S. W. Stratton* 652
The Cotton Oil Industry in the War. By *David Wesson* 652
Effect of Oxygen on the Precipitation of Metals from Cyanide Solutions. By *Oliver P. Watts* 652
Special Gold Recovery Processes Practiced by the Early Portuguese and Spaniards. By *E. Jordan* 653
The Western Chemical and Metallurgical Field....654
Built-in Laboratory Retort. By *F. E. Coombs* 655
Symposium on the Conservation of Tin....656
Calculation of Extraction in Continuous Agitation. By *Andrew Ham* and *Harrison Streeter Coe* 663
Importation of Optical Glass Controlled by the Government..666
Production of Hand Grenades....666
Commercial Uses of Chlorine. By *V. R. Kokatnur* 667
Basic Exchange in Permutite....671
The Development of the Ferro-Manganese Industry in the United States Since 1914. By *Theodore Swann* 672
Increased Production of Artificial Abrasives....673
Consumption of Chlorine Bleach Curtailed....673
Chemical Control of Water Softeners. By *Louis F. Clark* 674
Mobile Chlorine Water-Purification Plant. By *Robert K. Tomlin, Jr.*....678
Washing in Filter Presses. By *D. R. Sperry*....680
Fuller's Earth in 1917....682
Recent Chemical and Metallurgical Patents....683
Synopsis of Recent Chemical and Metallurgical Literature...684
Quantitative Determination of Suspended Tarry Matter in Gas. By *F. W. Steere*....686
Pyrotechnic Smoke Signals....689
Quicksilver Production in First Half of 1918....689
Personal....690
Obituary....690
Current Market Reports, Non-ferrous Metal Market, Iron and Steel Market, Chemical Market and Chemical Price List....690
Industrial, Plant Construction and Catalogs....695

Steel Conditions After the War

RECENT diplomatic and military developments have not indicated when the war will end, but they have suggested quite clearly that when the war does end it will end much more suddenly than was previously assumed. As to conditions that will exist in the steel industry after the war, accordingly, there is marked out a special period of transition from war time conditions to the conditions that will exist for a period of years after the war. There has been much discussion as to the demand for steel that will exist for several years after the war, for reconstruction and other purposes, but it is now clear that there is to be an intermediate period of transition. Some of the foreign belligerents have adopted more or less explicit reconstruction programs, which may or may not function well at the outset, while the United States has adopted nothing, and has not even settled upon a basis on which a program can be constructed.

It is regarded as an item of progress that the authorities at Washington have let it become known, unofficially, that they purpose to retain, after a declaration of peace, some measure of the control they have exercised over industry during the war. We have become so accustomed to the issuance of orders and requests, and compliance therewith, that it is somewhat difficult to realize how different basic conditions will be when peace comes. The War Industries Board is constituted to exist for six months after peace is declared, but the continuance of its authority is another matter. For illustration, the board's regulation of steel prices is the result of an agreement between it and the producers of steel. If the steel producers had refused to agree to the fixing of maximum prices, the President had the authority of the act of June 3, 1916, "in time of war or when war is imminent" to fix fair prices at which the Government would buy, and there was also the prospect, in case an agreement could not be reached, of Congress acting, as it did in the Lever act in the case of "food, feed and fuel." None of this applies to the period after the war, while furthermore effective regulation would cover not merely maximum prices, as hitherto, but minimum prices also, for it is distinctly stated that the regulation contemplated is intended in part at least as a protective measure to manufacturers. An agreement among producers would be necessary, and interesting questions naturally arise as to the legality of such operations.

Apart from the very difficult subject of Government regulation there is the fact that a large part of the steel demand that has been banking up is demand for steel for construction purposes. The investor must have an

idea of the conditions likely to exist during the period of years in which the investment is to yield revenue and return the principal. He cannot be expected to act hastily. His buying of steel is not likely to be a factor in the transitionary period. When the investor begins to buy, that will be a signal that the transitionary period is over and that business has settled down to the work of the period of years in which the world will rehabilitate itself.

As to international trade in iron and steel no subject could well be more confused. There are wide divergences between the set prices for steel products in the United States and Great Britain, and there are wide divergences in the profits vouchsafed to manufacturers by these prices. That there will be great readjustments in costs goes without saying, but where they will tend to land the industries in the various countries, as to international competitive conditions, is a conundrum. If it is to be a case of *laissez faire* a period of years will be required for the adjustment.

The importance of the changes in international competitive conditions in iron and steel that will result from the rearrangement of the Minette ore field appears to have been magnified by many who have undertaken to discuss that subject. It has been formally announced at Washington that return to France of the portions of Alsace-Lorraine taken by the Germans in the settlement of the Franco-Prussian war is part of the American program, as it has been right along of the French program. Some observers in the past have ventured to assert, as an argument on this subject, that the Germans need the ore and the French cannot use the extra quantity, but it is not necessarily a part of the peace program that international trade in this ore be prohibited. It flourished before this war, in the form of a complicated interchange of self-fluxing and siliceous ores, and it can be established on new lines, calculated indeed to furnish an additional safeguard that Germany shall not make iron and steel for military purposes. Important as the Minette ores are, the entire region has furnished the basis for much less iron production by France, Belgium, Luxemburg and Germany than the production in the United States. The mere difference between the greatest production of pig iron in the United States before the war and the present rate of production is more than one-half the production of all countries credited to the use of Minette ore.

Help For the Gold Producer

TO POINT out the distressing situation of gold producers is becoming almost hackneyed. Apparently their metal is much in demand, yet its selling price may not be increased despite the small production. Thus gold is one commodity which falls without the scope of that trusty sheet-anchor, the Law of Supply and Demand. The profits of most of these producers steadily aproach zero between the factors of diminishing ore tenure and increasing costs for labor, supplies and overhead. The situation is not local—from West Australia, South Africa and Canada comes the same plaint.

A well attended conference of Western producers, called by the Governor of Nevada, met at Reno in August. This meeting was a unit in asking for immediate relief and in condemning a change in price, but unfortunately it was able to suggest no path out of this evident *cul-de-sac*. This is distinctly unfortunate. If they, who are vitally interested in the ways and means of gold production and acquainted with its importance to industry and finance, can suggest no sound workable method of relief, it is idle to expect politicians or others to study cut the riddle. Thus it was that only the energetic propaganda of Western bankers succeeded in overcoming the general ignorance, suspicion and apathy of the recent meeting of the American Bankers' Association to a sufficient degree to have them refer the matter of gold supply to a standing committee for further investigation.

The Spokane Conference of Canadian and American producers held in September attempted to take this needed step in advance of its forerunner at Reno. After asking for a governmental investigation of the situation, it proposed several avenues of relief, any or all of which would be of material assistance. The exemption from assessment work, building of motor-truck roads, and extension of governmental credit would aid in the development of new producers and could readily be handled by a Minerals Administration. Priority of supplies, machinery and transportation and the allocation of labor can now be extended by existing governmental agencies in all countries, and in a very large number of cases would relieve the situation enormously. Under the circumstances it appears that an insistence upon these steps would be the best course of endeavor, since special class legislation toward pre-war freights and taxes would erect instant and powerful opposition.

It is unfortunate that after voting against a change in the present price, the conference fell into the inconsistency of proposing a bounty. One can hardly appreciate the specious arguments which led them to the delusion that a bounty is not tantamount to an increased price. Else in what currency are they to be paid? One flippantly might suggest that the bounty might be paid in zinc, thus coming to the aid of the zinc market at the same time gold is protected! Evidently it cannot be paid in gold, nor is it permissible to sell the metal on a free market. What a chance for a Get-Rich-Quick Wallingford if he could sell gold to jewelers for $25 an ounce and get his pay in gold notes!

Why cannot we recognize the fundamental reason before it is too late and disaster ensues? Commodity prices are too high for safety not only to gold production, but to the whole industrial fabric of our nation. They must come down before they pull the entire superstructure upon our heads.

Inscrutable in the Ultimate

THE Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research of Canada is publishing in installments a report of the Council's activities. The initial number is before us and we are informed that it is from the pen of Professor A. B. Macallum, the administrative chairman, and that it reflects more particularly his own views than those of his associates. In other words, that he is solely responsible for the opinions expressed. A large number of questionnaires have been sent to manufacturers and others and the returns, we learn, are in process of tabulation.

The value of such a body may be almost infinitely great, provided it undertakes its work with vigor, intelligence and understanding. On the other hand, unless it is exceedingly practical in coupling its efforts with measures relating to the general welfare, it is likely to lose public support, which is always a misfortune. Unnecessary duplication is another subject to be avoided, for research is research no matter where it is accomplished. One of the gravest errors made by the Germans was to cherish the belief that only they could practice applied chemistry. It was an expensive error.

Professor Macallum calls urgently and wisely for a great Institute of Research, and along with it he demands a Canadian Bureau of Standards. Now there is an excellent Bureau of Standards in Washington, the British standards are well organized and controlled in England and the two work together in harmony, but we have no desire to discourage the establishment of another bureau in the Dominion. If, however, they were to institute the metric system and were to co-operate with the French Bureau, some of us would wish them God-speed while others, both in the United States and Canada, might become addicted to tooth-gnashing, for to some minds the metric system is like a red rag to a bull. But there is no intimation of co-operation with France in the report.

Elsewhere Dr. Macallum expresses an opinion that seems to us to be pointed straight in the wrong direction. He says of Canadian industrial establishments that many of them are not in a position to undertake research on a large enough scale to insure results, which is perfectly true, in Canada and everywhere else. He says also that they can enroll themselves in American associations formed for the purpose of solving their problems by research and that some of them have already done so. Also true. He even says that such co-operation *may* be unobjectionable and that there are no international boundaries in science.

It is what follows that pains us. "There are reasons," says he, "why this co-operation cannot be erected into an international system. Some of these concern a cast of psychology inscrutable in the ultimate, if you will, but nevertheless potent in directing a policy on this question. Our people could not ultimately be brought to approve of any proposal, however luring it might appear to them, if also its acceptance involved an effacement of the pride and independence that nationality essentially predicates."

That sentiment appeals to us as rank poison. German propagandists have long been sowing the seed of just such ideas. If honest men of Canada and the United States engage in research for the general welfare, we are simple-minded enough to believe that they can be trusted to proceed without "ultimate" designs upon the well-being or estate or patriotism of their associates. The chicanery he refers to is the kind of chicanery we are fighting to stop. It is intelligent rather than slick or smart or sharp to engage in industrial research. The only safe way to play the industrial game is with the cards on the table. In the "ultimate" many citizens of the United States may move to Canada and *vice versa* for industrial purposes, and even that is no great tragedy. Both countries can stand it; both have resources enough and to spare without setting up a cry over it. We live side by side, we are neighbors, we are in the same fight for the same good cause and we cannot see the hazard that apparently is the basis of Dr. Macallum's suspicion. We sincerely hope that Canadian organizations for research and study will continue to welcome Americans as members and that our neighbors in applied science will continue to affilliate with such establishments on this side of the border. Let us put no barriers in the way of industrial research. We regret that Dr. Macallum has taken the attitude displayed in his official report.

The Development of Water Softening

IN THE eventful years around 1770, when BURKE was pleading the cause of the colonies before the English parliament and predicting the wonderful future growth of these vast territories on the far shores of the Atlantic, WATT, the inventor of the steam engine, initiated the means for bringing BURKE'S forecasts true, and LAVOISIER, the chemist, likewise gave the science of materials an impetus essential to the progress of the subsequent developments in engineering.

One of the most interesting features of the philosophy of the ancients was the theory that earth was formed from water. It was thus that they accounted for the islands and land apart from the seas, and there could be no dispute about it, because earth residues always accompanied the distillation of water. LAVOISIER, in his paper before the Académie des Sciences[1] in 1770, "On the Nature of Water and on the Experiments Adduced in Proof of the Possibility of Its Change into Earth," not only put an end to the water part of the time honored Fire-Water-Air theories of matter, but put the quantitative chemical science as instituted by JOSEPH BLACK and HENRY CAVENDISH on a firm basis in Paris, the capital of science at that time. Professor BLACK'S researches on "fixed air" (CO_2), burnt lime and the production of caustic potash form the premier study on quantitative chemical work. In subsequent years when boiler scale became important enough to command the attention of scientists, it was Professor CLARK of Aberdeen who profited from the work of BLACK and LAVOISIER and patented (1840) the softening of carbonated hard waters by neutralization with burnt lime. He thus started the cure of the trouble by the removal of the cause. In the eighty years of the Clark process, many improvements in both machinery and process have been made, which are so well known that they need not be described here.

Among the articles in this issue, considerable space has been allotted to the "Chemical Control of Water Softeners." The importance of water treatment is so fundamental to the needs of mankind that it has almost established a separate branch of engineering, located somewhere between chemical, civil and mechanical engineering. Recognizing that water treatment operations are not always under the control of men highly trained in stoichiometry and that softening machinery is often not installed, where needed, because it is considered too difficult to operate in small isolated operations, we are offering Mr. CLARK'S paper in the hope that it will answer the requirements better than any of the prior literature on the subject.

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[1] Œnores, II (p. 1).

Readers' Views and Comments

Consumption and Conservation of Tin

To the Editor of Chemical & Metallurgical Engineering

SIR:—The Bureau has noted your anonymous article under the above title on page 175 of the August 15 issue of CHEMICAL & METALLURGICAL ENGINEERING. Since the main part of this article follows an extract from a report of the War Industries Board, and from the wording of that extract it might appear that the comment on tin-base bearing metals and solders originated from the Bureau of Standards, we wish you would call your readers' attention to the fact that such is not the case. There are statements in the article to which we cannot agree and which might defeat the Bureau's efforts on tin conservation.

The Bureau of Standards has developed solder composed of 80 per cent lead, 10 per cent tin and 10 per cent cadmium which is being used as a successful substitute for ordinary solders. It has been tried in many industrial applications and has been found very satisfactory.

S. W. STRATTON.

Bureau of Standards,
Washington, D. C.

* * * *

The purpose of the article referred to was to indorse the movement for the conservation of tin and it would be unfortunate if it should in any way defeat the Bureau's efforts in that direction. Our statement to the effect that "metals such as cadmium have been tried as substitutes but are not of practical economic use" was based on the fact that cadmium costs per volume over three times as much as tin, oxidizes slightly above its melting point and does not give as strong a joint as regular solder. We are gratified to learn, however, that the Bureau of Standards has developed a satisfactory solder which should find wide use in view of the necessity of conserving tin. It should be needless to add that it is and has been at all times our desire to co-operate with the Bureau in its excellent work.

In a communication received subsequent to that published above, the Director of the Bureau states that while the relative cost of cadmium is greater than that of tin, only 10 per cent of cadmium is used in the substitute solder so that the entire metal cost of the cadmium-tin-lead solder is less than 35 cents per pound.—EDITOR.

The Cotton Oil Industry in the War

To the Editor of Chemical & Metallurgical Engineering

SIR:—In reading your very interesting account of the Cleveland meeting I noticed on page 548, Vol. 19, No. 7, a mis-statement in regard to the amount of oil which must be cleaned out of a ton of cotton seed. What I said was that it used to be considered good practice to get from 35 to 40 lb. of linters per ton of seed but the mills are now expected to obtain 145 lb. The price fixed on cotton seed varies by zones, according to the average amount of oil contained in the seed for each zone.

DAVID WESSON.

New York City.

Effect of Oxygen on the Precipitation of Metals from Cyanide Solutions

To the Editor of Chemical & Metallurgical Engineering

SIR:—The abstract on page 283 of your issue of Sept. 15th of the important paper by Mr. T. B. Crowe on the above subject has been read with much interest. While admiring Mr. Crowe's ingenuity in bringing about so great a saving in the cost of cyaniding by the simple expedient of removing the dissolved air before precipitation by zinc, the writer cannot agree with Mr. Crowe's views in regard to the mechanism of the process.

In opposition to his view that precipitation of gold is brought about by hydrogen which has been displaced by zinc, and that the removal of dissolved air is beneficial because it prevents oxidation and loss of this reducing agent, the writer considers that the gold is directly displaced from solution by zinc, just as the same metal displaces copper from a solution of copper sulphate. The dissolving of zinc in a solution of pure sodium cyanide is a case of the displacement of one element by another, and differs from the dissolving of zinc in copper sulphate only in that hydrogen is displaced instead of copper.

It is this difference in the material displaced from solution that makes oxygen a necessity for the rapid dissolving of zinc or other metals by cyanide solutions, while the presence or absence of oxygen has no marked effect on the rate of dissolving of zinc in a solution of copper sulphate. If a strip of zinc be placed in an excess of dilute sulphuric acid the metal begins to go into solution and hydrogen is displaced; because the potential of zinc, or its tendency to dissolve, is greater than the discharge potential of hydrogen on the same metal, i.e., the force required to precipitate hydrogen, this action continues until all zinc has disappeared. If, however, the zinc be amalgamated, it is no longer appreciably attacked by the acid, although after amalgamation the zinc shows practically the same potential as before; it is because the discharge potential of hydrogen on mercury is greater than the potential of zinc in sulphuric acid that there is no visible evolution of hydrogen on amalgamated zinc. The displacement of hydrogen undoubtedly begins, but the potential of the cathode in the voltaic cell constituted by the mercury and zinc is raised by the layer of accumulating hydrogen until it equals the potential of zinc. When this occurs, dissolving of the zinc must cease. If now an oxidizing agent be added to the acid, or air be blown in, the zinc will dissolve, for removal of the film of hydrogen by oxidation enables the zinc to displace a new quantity of hydrogen. In this way the dissolving of zinc will continue so long as the hydrogen which it displaces is continually removed.

In a solution of sodium cyanide ordinary zinc acts like amalgamated zinc in acids, i.e., the hydrogen which the zinc displaces when it dissolves must be removed from the surface of the metal in order that continuous solution of the zinc may occur. When zinc is immersed in a dilute cyanide solution containing gold,

two reactions occur side by side; first, some of the zinc is dissolved by the double cyanide of gold with precipitation of gold; second, a portion of the zinc dissolves in the sodium cyanide with the displacement of hydrogen. Only the first action is useful. Every gram of hydrogen that appears means that 32.5 grams of zinc has dissolved without precipitating any gold, and that the amount of cyanide with which this zinc has combined is also wasted. Fortunately this wasteful dissolving of zinc is strictly limited to the amount of oxygen or air available for oxidizing the polarizing film of hydrogen.

Besides causing a loss of zinc in the manner indicated, dissolved air lessens the efficiency of recovery by accelerating re-solution of the gold already precipitated, just as air aids the dissolving of metals in cyaniding ores. It is this two-fold action that makes dissolved air a factor to be reckoned with in the economics of gold recovery.

OLIVER P. WATTS.

Chemical Engineering Dept.,
University of Wisconsin.

Special Gold-Recovery Processes Practised by the Early Portuguese and Spaniards

To the Editor of Chemical & Metallurgical Engineering

SIR:—When I had the pleasure of reading your number of METALLURGICAL & CHEMICAL ENGINEERING of June 1, 1918, I came across a very interesting letter, page 565, entitled "Special Gold-Recovery Processes Practised by the Early Portuguese and Spaniards," and I was the more interested in it as I have a personal experience of over nine years in gold mining in the State of Minas (Brazil), and I can therefore assure you that the facts related by Mr. Kirby Thomas are quite correct, and that this process is still being used now-a-days not only by the natives, but also by the most up-to-date gold mines in that country.

There is not the slightest doubt that it saves a fair amount of gold which would be lost by flotation.

It was specially used by the mining companies I was working with to facilitate the final obtention of the free gold in the *batea*. This primitive instrument (of African origin, if I am not mistaken and therefore probably invented by the early Egyptians) is nevertheless very efficient, and it is regrettable that its use is not more general outside of Brazil.

The plants yielding the sap which is employed to precipitate the floating gold are very numerous, but nearly all belong to the *solanea*, and the juices of this species are always slightly alkaline. Practically, however, only the sap of the plant called *jurubeba* is used by the natives—this mainly on account of its large leaves, which facilitate the obtention of a fair amount of sap without having too much trouble in gathering the primitive material needed. These leaves are roughly crushed by hand in a mortar and the whole pulp together with a small amount of water is put in a cloth and wrung to press out the liquid, which can then be used directly to precipitate any floating gold.

To do this, part of the water on top of the very rich sand contained in the bottom of the *batea* is drained off till the concentrates are uncovered. Some small particles of gold being thus allowed to dry would naturally float if more pure water was added to continue concentration. To obviate this the operator scoops up in his hand an amount of the *jurubeba* juice kept in a special vessel, and sprinkles it very vigorously over the concentrates contained in the *batea;* and then adding the necessary amount of *jurubeba* juice, finishes the cleaning of the gold by skillful action of the *batea* without losing any gold by flotation on account of the vegetable liquid used.

I may add that the chemist in charge of the reduction department of that mine devised a strake concentrator in which the sap of the *jurubeba* was used instead of water to further concentrate the sands from the stamp strake, the solution being kept in circulation by a small centrifugal pump, it being naturally filtered after leaving the canvas-covered strakes and before being sucked up again by the centrifugal pump.

Personally I cannot give a very definite explanation of the action of the *jurubeba* juices, but I believe the action is just a cleansing process.

For instance, in the case of the floating needle which will not float if it has been cleansed or washed thoroughly with soap or sand-papered so that no particle of grease remains, it is sufficient to pass the needle through the fingers, or better still through the hair to restore its floating properties, showing very clearly that it is only necessary to have an infinitesimal film of greasy matter which naturally does not allow the water to wet the needle, and thus forms the depression on the surface of the water which supports the needle. And further I may note again that if you use instead of water a very slightly alkaline solution, the needle will not float, this being sufficient to neutralize the grease.

Now for this reason I think that the action of the *jurubeba* juice is very similar to this, because you must remember that the stamping process, as well as the friction in the *batea*, tends to polish the gold flakes, and they are therefore with difficulty wet by common water, but easily by the *jurubeba* juice, it being as aforesaid slightly alkaline.

Moreover the Portuguese when treating refractory ores used to slime the concentrate by grinding it under two flat stones, which form a small arastra, a process they used to call burnishing, showing you well that the small flakes of gold enclosed were polished.

Resuming I may say that this action of the vegetable sap of the Brazilian plants has quite a contrary effect to the one in the flotation process, as instead of trying to make the mineral particles float they try to make them sink, but the phenomena are explanatory of each other, as in the flotation process you try either to grease the mineral particles by the use of a small proportion of oil or create a gaseous film around these particles by acids which react on the concentrates, this gaseous film not allowing the mineral particles to be wet, just as the oil did it in the previous case, although in the latter case the gaseous film clinging to the mineral particles reduces at the same time their specific gravity.

In closing it may be interesting to note as an illustration of the skill acquired in working the *batea* that I tried an experiment with one of the women who was particularly clever in its use at the mine. To ten pounds of straight sand (the amount held in the *batea* ordinarily) I added 0.10 grams of fine assay gold which the woman then washed by the above method, and at the last she returned to me from the precipitate at the bottom of the *batea* 0.09 grams.

E. JORDAN.

240 Quebec Ave.,
West Toronto, Canada.

Western Chemical and Metallurgical Field

Molybdenum

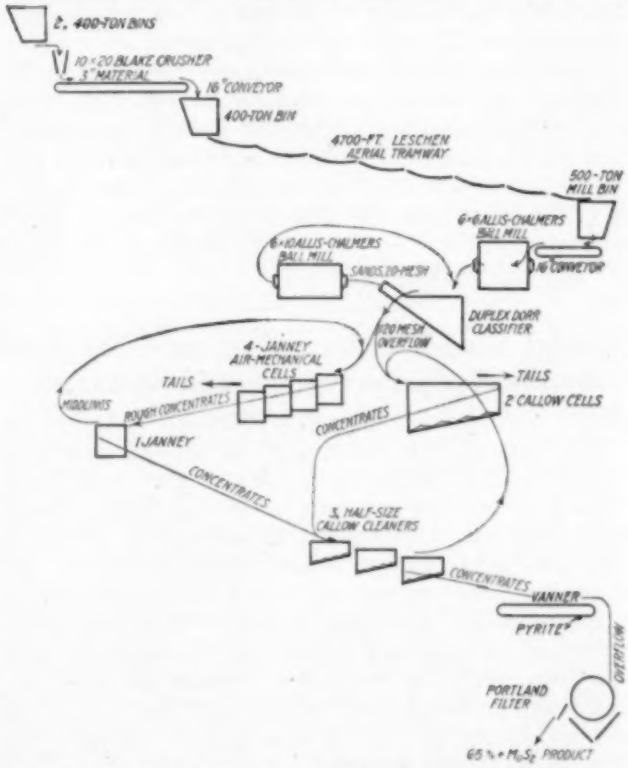
Quebec and Queensland have both been claiming the honor of having the largest producer of molybdenum. Quebec has the Moss mine in Onslow township, operated by the Dominion Molybdenite Co., which was largely responsible for the 210,000 pounds produced in that province in 1917. On the other hand, Queensland's output was 250,000 pounds, coming mostly from the famous Kitchener mine. This controversy has been definitely settled by the operations near Climax, Colo., where the Climax Molybdenum Co., a subsidiary of the American Metal Co., has rushed a 300-ton mill to completion, and in the near vicinity the Molybdenum Products Co. is putting its 250-ton mill into operation. The Climax Company is now producing at the annual rate of 1,250,000 pounds of molybdenite, and even this figure will be further expanded to a quantity greater than the previous world's production when the present construction is completed, which will increase the capacity of its mill to 1000 tons per day.

Molybdenite in the Summit County (Colorado) deposits occurs as very fine particles in quartz veinlets throughout a large fractured zone in siliceous granite. The ore-body will be mined by a caving system and concentrated by flotation, a flow sheet of the Climax mill being shown in the accompanying sketch. It contains 0.92 per cent molybdenite (the oxidized metal being calculated to its equivalent of MoS_2), 2.7 per cent iron, a trace of copper, and none of the other deleterious substances such as arsenic, bismuth or phosphorus. In order to make a product containing a minimum of 65 per cent MoS_2 and a maximum of 10 per cent iron, it is evident that a great deal of iron sulphide must be left behind in the cells, or eliminated as a concentrate on a vanner. Much difficulty is therefore experienced in getting a high-grade product from the final cleaner cell, which has been cut down in size materially, since only about four pounds of concentrate is recovered per minute.

According to Keeney, no difficulty is experienced in making a ferro-molybdenum containing below 0.1 per cent sulphur from a molybdenite concentrate when smelting in an electric furnace with carbon as a reducing agent and with excess lime. The reaction is: $2MoS_2 + 2CaO + 3C = 2Mo + 2CaS + 2CO + CS_2$ The product will contain about 1.3 per cent carbon, and as much iron as is introduced to make the required ferro. Standard alloys have not yet become established on account of the disfavor which molybdenum apparently enjoys with American steel manufacturers.

The market exhibits puzzling peculiarities. In the middle of 1916 the demand for molybdenite greatly increased, and the 95 per cent product commanded about $2 per pound throughout 1917, which was nearly ten times its pre-war price. Encouraged by these prices several small producers in the Rocky Mountains and on the Pacific Coast equipped their properties to produce a salable concentrate only to find that for several months just past there has been but a nominal quotation.

Reliable information as to the actual consumption of molybdenum is extraordinarily meager. It is said that prior to the war Germany absorbed practically the whole world's production, having become expert in its use as an alloy to make gun tubes highly resistant to the wear and heat of continual firing. However, the only authoritative analyses we have seen of captured German cannon stated distinctly that no molybdenum was found. The large demand during 1916 and 1917 is widely credited to the British and French munitions boards. Information as to the ultimate destination is naturally



FLOW SHEET OF CLIMAX MOLYBDENUM CO. 300-TON MILL

not obtainable, but the sudden drop in exports indicates either that their needs are supplied elsewhere or by a substitute, or else that the use of the molybdenum proved disappointing and is being discontinued.

Apparently no great amount of molybdenum is being used at the present time in America. The reasons ascribed are various. One is that American metallurgists are not capable of making the addition nor executing the heat treatment properly, and engineers are just now returning from the other side with the necessary information. Another is that the consumers of steel will have to be educated to the proper uses of the new alloys. Still another says that the correct heat treatments and compositions are patented and free use is thus restricted. Finally, one is told that when an adequate supply of molybdenum is developed sufficient to warrant the production of its alloys in quantity, the steel manufacturers will readily absorb it.

Swinden, in the "Carnegie Scholarship Memoirs," Vol. 5, 1913, p. 100 (British Iron and Steel Institute), has published the results of his extensive studies on carbon-molybdenum steels. From this and previous knowledge, it appears that molybdenum acts very similarly to tungsten as far as its influence on critical temperature, hardening power, and physical properties are concerned, and is from two to three times as potent in producing these results. Following Frederick W. Taylor's classic "On the Art of Cutting Metals," how-

ever, the impression is abroad that molybdenum alloys are more brittle than the corresponding tungsten equivalents, and are very tender under heat treatment. Thus the ordinary class of labor and equipment in the hardening room will give non-uniform results, which of course is fatal to its use in high-speed tools or modern ordnance.

Built-in Laboratory Retort

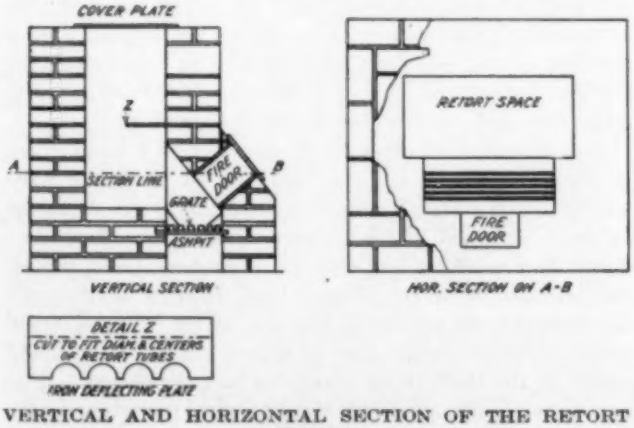
By F. E. Coombs

THE field of research in dry distillation is daily widening and increasing in importance. So far, there has been nothing offered in the way of experimental apparatus, either for operation on a small laboratory scale, or for commercial testing with large quantities. This article is descriptive of a still which has been in actual service found very easy to handle and entirely practicable, allowing the collection of gases as well as condensibles, and the isolation of all of the carbonized residues for exact weighing. It is especially valuable for finely divided materials, and for all high-temperature sublimations of non-corrosives.

In the accompanying drawings dimensions are not shown, as the scale will be sufficient guide. It is also to be noted that the header and cover-plate of the retort proper will be made of a suitable width to give a flange of about three inches, inclusive of the recess for the metallic seal, and that a clearance of about one-quarter inch should be allowed for around the tube openings, to give easy handling of the sheet metal containers.

The apparatus as scaled in the assembly sketch of the retort carried, in its four tubes, about fifteen pounds total of rather light powdered material, and the 4-in. diameter permitted complete carbonization in about thirty-five minutes.

The essential parts comprise two castings, of which

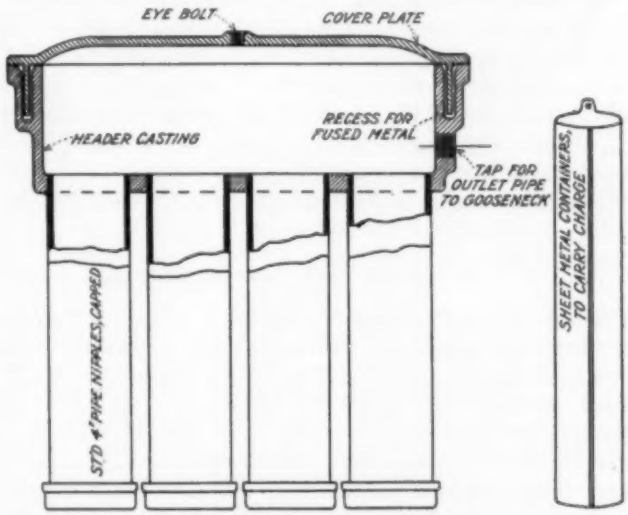


VERTICAL AND HORIZONTAL SECTION OF THE RETORT FURNACE

one is a chambered header with four threaded holes for the capped pipe nipples, and at its upper end a flange and a deep, narrow recess, to be filled with lead, or any alloy of convenient melting point, and further provided with a boss tapped for the outlet pipe, which pipe should be not less than 1½ in. in size. Upon the flange of the header casting rests a cover member, tapped for a strong ring bolt and having a continuous web, vertical to the flange, which fits very loosely into the recess of the header, and should seal therein in the fused alloy to a depth of about 2½ in. at the least.

Eight sheet-iron carrier cylinders are made which fit easily into the capped pipes, without binding, and a perforated ear on each gives means for attaching an iron hook. With these containers the finished charge can be taken out and the newly filled set inserted in less than two minutes from opening the furnace to closing it again with a fresh charge.

The bottoms of the containers can be permanently closed; but in apprehension of trouble in cleaning out char, the sets actually made were merely flanged over inwardly at the bottoms, and loose round caps of sheet



CROSS-SECTION OF RETORT SHOWING HEAD, COVER AND CONTAINERS

metal used for closing. This was absolutely satisfactory, and no leakage occurred in filling or retorting.

The retort should be set in a brick furnace of proper form, which may be like the one shown and used, but in any case must have a deflecting wall, or plate, for securing a back-and-forth passage of the gases, so that the top will be heated as well as the bottom.

Over the top of the furnace is a pulley and rope, with an iron hook to fit the ring in the furnace top plate and the one in the retort cover-plate. The same rod may be used for removing the containers, but it will be found better to use a separate hook-rod for these, so that they may be swung freely to the closed can used for preventing the combustion of the red hot coke of the discharge.

The exit pipe, or gooseneck, will project through one end of the furnace wall for connection to condenser.

The empty retort and cover are heated first, and the lead permitted to melt in the recess. When hot enough not to "freeze," the prepared containers are rapidly dropped into place, and the cover plate and furnace cover laid on. Distillation starts almost at once, but not too rapidly, as the capped pipe nipples will have just lost redness by the time the new charge is set in and the cover is on. Header free space is large enough to give a dust chamber, and sudden expansions or excessive gas evolutions may lift the cover but will not damage the apparatus. All or any less number of the carriers may be inserted, according to the freedom of evolution, and the retort is free of the furnace wall.

While the right to patent protection is reserved on large commercial forms of this design, the use of a four-chambered apparatus of 100 lb. capacity, or under, is open to public use.

Floriston, Cal.

Symposium on the Conservation of Tin

A Discussion of the Tin Alloys—Bearing Metals, Solders, Bronzes and Substitutes—Conservative Spirit Displayed—Considerable Data Being Compiled by the Bureau of Standards on the Use of Cadmium Substitutes

AT THE Milwaukee meeting of the Institute of Metals Division of the American Institute of Mining Engineers held Wednesday morning, Oct. 9, several most prominent metallurgists read papers connected with our present tin situation. MR. GEORGE C. STONE called the meeting to order. MR. W. W. COWAN read DR. G. W. THOMPSON'S paper in which he endorsed the increased use of lead in solder and bearing metal alloys.

THE COPPER-BASE BEARING METALS

MR. G. H. CLAMER gave an excellent review of the use of lead in copper-base bearing metals as follows: In the early days, copper-tin alloys were almost universally used, the idea then being prevalent, and is still held by many, that a bearing to resist wear must be hard, and the harder the better. The favorite bronze bearing contained 90 per cent copper and ten per cent tin; frequently, in service which was considered severe, even higher proportions of tin were used. Such hard alloys have great resistance to compression, but as a rule they had a very wide factor of safety in this respect. Such bearings, because of their inability to adjust their surfaces to slight irregularities in the journal, or to foreign bodies, immediately begin to cut, and heating results. With a slight rise in temperature, the film of lubricant becomes thinner, and further cutting follows, if not actual gripment of the bearing with the journal.

Many years ago Dick, of England, appreciating the advantage to be derived from a slight plasticity in a bearing, added some lead to the then standard bearing metal, not substituting lead for tin but reducing the copper, and produced the alloy, which has long held favor as a bearing metal, copper 80, tin 10, lead 10 per cent. Dick's alloy also contained some phosphorus, but the main point is that this was the first step toward the production of bronze alloys having a plastic nature. Lead does not unite to form an alloy with copper, but remains mechanically mixed, so that structure of the alloy is that of a hard matrix with the soft metal imbedded therein.

It was not until several years later that tests were conducted on the Pennsylvania Railroad, under the direction of Dr. C. B. Dudley, who investigated the copper-tin-lead series within certain limits of the 80-10-10 alloy; he studied, not only the alloys containing lead above 10 per cent in which copper was replaced by lead, but also in which tin was replaced by lead. His conclusions, which have since become firmly established, are: (1) The rate of wear diminishes with increase of lead in the alloy. (2) The rate of wear diminishes with decrease of tin in the alloy. Fortunately, the alloy containing least tin and highest lead exhibits least tendency in service to give trouble from heating.

Notwithstanding the decided merit of copper-tin bearings containing lead, prejudice was strongly against them, simply because lead is a low-priced metal. It was even intimated that such alloys were frauds, should be considered such, and dealt with accordingly.

I have mentioned Dr. Dudley's discoveries because it was due to its findings that the Ajax Metal Co. instigated research work, now 20 years ago, which has led to the production of alloys still higher in lead and lower in tin than those which he was able to produce. He experienced foundry difficulties which apparently limited his maximum lead alloy to 77 copper, 8 tin, and 15 lead. This was called Experiment B alloy, and has since been widely known as "Ex. B metal."

Having found due regard to the raw materials used, and by following good foundry practice, we have been able to produce alloys carrying 5 per cent of tin and as much as 30 per cent of lead which would show no segregation of lead, even if cast into large bearings. By this I mean that such bearings will show no indication of metallic lead upon any surfaces. Lead being only mechanically held in the alloy, it is prevented from segregating by the quick setting of the matrix of copper and tin. As a certain interval must necessarily occur between the time when the metal enters the mold and the time when it solidifies, the lead always shows some tendency, owing to its high specific gravity, to liquate toward the bottom of the casting. In bearings made of the proper raw materials, and correctly handled, the difference in the proportion of lead is not usually over a fraction of one per cent, or at most 2 or 3 per cent, the top and the bottom of a casting, even if this be a fairly large one, and made of the 30 per cent lead alloy.

I do not wish to repeat here data which I have given in previous papers[1] but I do wish to set forth the position which the high-lead and low-tin alloys developed by us have attained. When these alloys were first produced they were backed only by laboratory tests and by the predictions of Dr. Dudley that, if such alloys could be commercially produced, the law which he established would no doubt apply also to alloys higher in lead and lower in tin than those which he had developed. It is now possible for me to review 18 years' experience with the manufacture and service of such bearings. I must confess that in our enthusiasm over the valuable properties of these alloys, we were led at times to overstep the mark and place such bearings in service where the loads or the impacts were too great.

The first requisite of a bearing is that it shall be sufficiently hard to support its load or to resist the impacts to which it may be subjected, and the relation of tin to lead must be controlled by this requirement. We have sometimes made mistakes in recommending the copper

[1] Jnl. Franklin Inst. (July, 1903), 156,495. Proc. Amer. Soc. Testing Materials (1907), 7302. Amer. Inst. Metals (1915), 9241.

65, tin 5, lead 30, alloy for certain mill bearings, but this did not have sufficient resistance to compression, and failed for that reason. When the copper 73, tin 7, lead 20 alloy was substituted the bearings exhibited no deformation and performed far better than the 80-10-10 alloy previously used. We have also noted the failure of the 73-7-20 alloy on rod bearings of very heavy locomotives. Locomotive rod bearings are subjected to severe impacts and it is necessary therefore to use an alloy of fairly high compressive strength. Although the above alloy performs satisfactorily on light locomotives, on the rod bearings of heavy locomotives it is necessary to use either the 80-10-10 alloy or the same alloy to which has been added approximately 1 per cent of phosphorus. The size of these bearings, and hence their bearing surface, is narrowly limited by necessities of construction; otherwise these harder alloys would not be essential for this purpose. Phosphorus greatly increases the compressive strength of such an alloy, and is for this reason a possible factor for conserving tin. At the present prices of tin and phosphorus there is little choice; an alloy with 8 per cent of tin and 1 per cent of phosphorus will have compressive strength approximately equivalent to the alloy having 10 per cent tin. Experience, thus, has demonstrated that alloys containing as little as 5 or even 4 per cent tin and as high as 30 per cent lead, can be used in railroad service for the densest traffic. They have become the standard of the United States Railroad Administration for car-journal bearings called for under their Specifications R-71 Grade A. Such an alloy is also included in the specifications covering locomotive bearings designated as Specification R-72, Soft Bronze.

In my judgment, the specifications of the Railroad Administration covering locomotive bearing-metals are very satisfactory, except that the use of soft bronze should be extended to cover driving brasses, and engine and trailer-truck bearings. Before the Railroads of the United States came under Government control, copper alloys with low-tin and high lead contents had become the standard specifications of several of the large car companies, and were very extensively used on the largest railroad systems. Outside of the railroad field they had also been widely recognized and used. The advantage of using the smallest possible amount of tin consistent with the load requirements is now so well understood that there is but little opportunity for an important conservation of tin in this field.

Let us next consider the possibilities of substituting some other metal for a part or all of the tin in a copper-tin-lead alloy, or of substituting alloys of an entirely different type.

The first metal that presents itself as a substitute for tin is antimony. Antimony combines readily with copper and with lead, and has the property of adding hardness. Unfortunately, however, the hardening effect of antimony is obtained with the sacrifice of ductility. We have found it possible to make alloys carrying as high as 30 per cent of lead with 3 per cent of tin and 2 per cent of antimony. We have also made alloys of 65 copper, 30 lead, 2 tin. and 3 antimony, and have also replaced the 5 per cent of tin in this alloy entirely with antimony. Car bearings 4¼ x 8 in. size made from the same pattern and subjected to a breaking stress applied longitudinally at the middle of the back of the bearing and throughout its entire length, broke at the following average loads: with 2 per cent antimony substitution, 60,000 lb.; with 3 per cent substitution, 62,000 lb.; with total substitution, 52,000 lb.; as compared with a breaking load of 67,000 lb. for the alloy of copper 65, tin 5, lead 30. The castings produced with each of the three above-mentioned alloys are not so satisfactory as those made with the straight tin alloys, being more or less rough, and showing slight globules of lead on the surface. It has been found that a certain amount of nickel can be used for replacing tin with very satisfactory results. The castings produced when zinc is substituted for a certain amount of tin are decidedly unsatisfactory. The substitution of aluminum for tin is entirely impractical, and such castings are worthless. This does not, however, exhaust all the possibilities of substituting other metals for tin in the copper-tin-lead alloys, but it is my opinion that the substitution of any other metals, in those alloys, can be made only by sacrificing the quality of the alloy.

The possibility of substituting alloys of an entirely different type presents an attractive field for research. The copper-tin-lead alloy has attained its position as the most desirable bronze bearing alloy, but this does not mean that some other alloy may not be found which may give equally good or better results. In the search for such a substitute alloy it should be borne in mind that a bearing metal should possess the following properties:

1. It should be sufficiently rigid to support the load or resist the impact, but yet not so brittle that it will easily crack.
2. It should have as great a yielding or plastic nature as is consistent with its ability to support the load or resist the impact without deformation of the bearing as a whole.
3. The ideal structure combines a hard matrix to support the load and a softer metal or alloy contained within such matrix, to permit the bearing surface to adjust itself to irregularities of surface.
4. It should be easy to handle in the foundry and machine shop.
5. It should be capable of being remelted without deterioration.
6. For use in babbitt-lined bearings, it should be capable of being tinned, so that the babbitt can be applied thereto.
7. It should have good heat conductivity in order to dissipate the heat generated by friction.

Pennsylvania Railroad Anti-Friction and Bell Metals

Mr. H. M. Waring gave an interesting account of the approximate composition of the non-ferrous alloys in general use on the Pennsylvania Railroad as follows:

	Copper	Tin	Lead	Phos.	Antimony	Zinc
Phosphor bronz, spec. 32-C	79.70	10.00	9.50	0.80	.....	....
Ex. B. bronze, spec. 141	76.75	8.00	15.00	0.25	.....	....
Special high lead bronze, spec. 59	70.00	5.00	25.00	.....	.....	....
Lining metal spec. 57	.....	.....	87.00	.....	13.00	....
Dandelion metal	.....	10.00	72.00	.....	18.00	....
Bell metal	83¼	16¾	.....	.....	.....	....
Babbitt, tin-base	3.70	88.90	.....	.....	7.40	....
Babbitt for motor bearings	1.00	50.00	38.50	.....	10.50	....

Phosphor bronze is used principally for rod bushings, main-rod brasses, and crosshead shoes.

Ex. B bronze is used to a small extent for backs of car and coach bearings, but the majority of these are now made of the car-journal bronze, which contains, on the average, about 5 per cent tin.

Car-journal bronze is used for making car and coach bearing backs at the Altoona brass foundry, by melt-

ing down old backs after removing the linings and making the necessary addition of new metal to bring the composition within the limits containing not less than 71 per cent copper, 4 per cent tin, 13 per cent lead and more than 0.20 per cent phosphorus and 3 per cent zinc. No new tin is added in making this alloy.

Special high-lead bronze is used principally for locomotive driving-box shells, which are not lined.

The lead-base lining for car journal bearings was formerly made up in our foundry from lining metal melted off from old bearings and brought up to specification requirements by the addition of such new metal as might be necessary. Some tin was unavoidably introduced from the old bearings, but the amount allowed in the metal was limited to 2 per cent. Lately we have been using this old lining metal in the preparation of the lead-base dandelion metal babbitt, thus making use of the contained tin in order to reduce the amount of new tin which it was necessary to add to this metal. The journal-lining metal is then made from lead and antimony without the addition of any tin.

Lead-base dandelion metal babbitt, containing about 10 per cent tin, is used for lining cross-head shoes and also for lining engine truck and trailer bearings, as well as for hub liners, in place of phosphor bronze, on freight locomotives. This metal has replaced a large amount of tin and tin-base babbitt formerly used.

Bell metal is used exclusively for making locomotive bells, and during 1917 about 42,800 lb. of castings were made, involving the use of a little over 7000 lb. of tin.

Tin-base babbitt metal (88 9 tin, 3.7 copper, 7.4 antimony) is used for a number of miscellaneous purposes in the shops, but its use has been greatly restricted and every effort is being made to do away with it where possible, and to substitute a lead-base babbitt or a babbitt with 50 per cent tin.

The amount of solder having the composition 50 lead, 50 tin, used by the Pennsylvania Lines East, during 1917, was approximately 100,000 lb. but there is reason to believe that a large portion of this can be replaced by a 60-lead, 40-tin solder with satisfactory results, and instructions have been issued to this effect.

In regard to the quantity of new tin used, it is not possible to give the amount except approximately, and from calculations based on the 1917 consumption of bearing metals by the Pennsylvania Lines East only, it is estimated that about 770,000 lb. of new tin were required in a total of about 21,380,000 lb. of all kinds of bearing metals turned out by the foundry or purchased in the market.

No change has been made in the specifications for bearing metals for some years, as the metals used have been satisfactory. A large proportion of the bearing metals are made up from old material re-melted and brought to standard composition by some addition of new metal, and every effort is being made to utilize old material to the best advantage and reduce the amount of new metal of all kinds purchased. For a number of years no tin has been used in the lining metal of either passenger or freight car journal-bearings, except such small amounts as come in from re-melting old linings. No change has been made in phosphor bronze used for rod bushings, as we should expect some trouble from bushings pounding out of shape if a phosphor bronze were used which contained less tin or more lead than the present specifications call for. In this, as well as in the case of all other bearing metals, we expect to use our utmost endeavors to economize and to substitute for tin wherever possible.

Solder, Its Use and Abuse

Mr. Milton L. Lissberger gave an excellent account of the properties of lead and tin alloys and the procedure of manufacturing commercial solders as follows:

Solder is a mechanical mixture of tin and lead. This is susceptible of a very quick and simple demonstration.

A bar of solder passed through a buffing machine even of a grade as low as 30% tin and 70% lead will show a surface practically identical with a bar of second quality or reclaimed tin.

The buffings when subject to a chemical analysis will show almost pure lead.

Now then, let us examine the reasons of this. Under the very best practice solder is made by first melting down the virgin pig lead. When the lead is absolutely liquefied virgin pig tin is added and a small amount of flux, the flux being for the purpose of bringing to the surface the so-called liver of metal that may have remained in either the lead or tin through incomplete refining.

The entire material when completely liquid is then thoroughly stirred for some hours. This mixture is next cast into small pigs. Just before casting into pigs, and continuously while this operation is going on, the kettle of molten metal is producing what is commonly called dross, but which in a great measure is actually the oxide of lead and tin, and this should be carefully skimmed off.

After these pigs of metal have been completely cooled, they are taken to a smaller kettle, remelted and cast into the desired shape for use, or if to be made into wires, ribbons, etc., are cast in slugs suitable for extrusion and rolling.

While this second operation is taking place, the skimming of the so-called dross should be, if anything, much more carefully done that when it is being cast into pigs.

Hand mixing has been proven as the only absolutely reliable method for the production of the best quality of solder. This means quality irrespective of the percentages of lead and tin that enter into the solder.

This last statement is made in view of the fact that the best quality of solder does not at all times mean the solder that contains the highest percentage of tin. The best quality of solder, as far as the proportion of lead and tin contents are concerned, is that composition which best performs on the required piece of work.

At this time, it is well to consider what does take place in the mixing of the lead and tin, and why there is a necessity of stirring for such a long period of time.

As stated at the outset, lead and tin do not form an alloy; therefore, to get a mechanical mixture as near perfect as it is possible to do, it is necessary to stir for a long period so as to break up the tin and lead into as small particles as it is possible to do, and to have these particles of lead and tin intermix.

Experience has shown that to perform this operation to the highest degree possible takes between five and

six hours, and this is irrespective as to the quantity of material being mixed.

Further, the difference in time is inappreciable between a mixture high in tin and one low in tin running in a commercial way down from 60 per cent tin to 30 per cent tin.

When the solder is first cast into pigs, and all through the casting process, what takes place is that the tin solidifies in the form of a skeletonized mass. In the interstices of this skeleton rest the small globules of lead.

It is remarkable how many shapes these interstices take. The seeming explanation of these various shapes is the amount of other material present than tin and lead; hence very small, in fact it might be called chemical trace of foreign material present in the mixture causes a variation in shape.

To put this plainly, in a mixture made of chemically pure lead and chemically pure tin, the formation of the tin skeleton will differ from a material made where there is so much as one thousandth of one per cent of impurities.

As a further proof of the fact that solder is not an alloy of tin and lead: it would be found on examining the pigs first cast that there has been a segregation of the tin and lead equivalent to about one percent per perpendicular inch of height.

Taking a mixture of 50 per cent tin and 50 per cent lead, and casting it in a block six inches high, examination of scrapings made from the bottom of this block shows a composition of 47 per cent tin, 53 per cent lead. Borings made one inch from the bottom show 48 per cent tin, 52 per cent lead. Borings made two inches from the bottom show 49 per cent tin, 51 per cent lead. Borings made three inches from the bottom show 50 per cent tin, 50 per cent lead. Borings made four inches from the bottom show 51 per cent tin, 49 per cent lead. Borings made five inches from the bottom show 52 per cent tin, 48 per cent lead. Scrapings made from the top show 53 per cent tin, 47 per cent lead.

Now, you may mix as long as you want, but you cannot overcome this segregation provided the liquid solder is cast for the full six inches at one casting. Should, however, you cast one inch at a time into your mold, allowing it to cool before casting the next inch, you will find you are overcoming in a measure this segregation, but there is still a decided difference in the tin contents of the scrapings made from the bottom and the top of the pig.

Mr. Lissberger divided solder into two classes, that which is used strictly for soldering purposes, or the joining and holding together of pieces of metal, and second, that which is used primarily for filling, in which the joining is a secondary consideration.

He thought that the greatest abuse of solder is in the use of high tin mixtures for these filling metals. A mixture of 25 per cent tin and 75 per cent lead worked at the proper heat and with proper fluxing, he declared to be high enough for any filling purpose. This has been demonstrated in the practice of the oil canners, particularly the Standard Oil Co. The best means of conserving solder in can making, it was suggested, is to deepen all baths whether on line machinery or for hand dipping. Overheating of the baths should be avoided and the top of all baths covered with a protecting material, as sal ammoniac, oil, charcoal or ash.

Mr. Lissberger lamented the great waste of tin in the failure of many plants to save their dross. He gave his opinion that a 46 parts tin, 54 parts lead and ½ part antimony makes the strongest solder, though for machine work, as low as 38 per cent tin has given satisfaction. Later during a discussion before the meeting, Mr. Lissberger spoke at length concerning the substitution of cadmium for tin in solder and was very emphatic in stating the defects of this type of solder, though he did not specifically denounce the new 80-10-10 solder.

The Tin-Plate Industry

Mr. Stone read the following from the paper of Mr. M. D. Buck: During the first 5 months of 1918, approximately 11,000,000 lb. per month of pig tin were consumed in the United States. Solder bearing metals, bronzes, etc., used about 5,500,000 lb.; collapsible tubes a little more than 250,000 lb.; tin-foil about 500,000 lb.; and the tin- and terne-plate industry somewhat less than 5,000,000 lb. In an effort to reduce this consumption and thus conserve our tin supplies, several methods of procedure suggest themselves:

1. Salvage. The most careful and systematic collection and re-use of tin and tin-bearing materials is economically important, in that we thus secure the maximum benefits from our available supplies.

2. Substitution of other materials for tin. While tin, on account of its low melting point, softness, malleability, non-toxicity etc., is peculiarly adapted for many uses, nevertheless it may seem desirable, during times of temporary stringency at least, to substitute for tin and for tin-bearing materials some other substances which may answer our purposes, though perhaps not possessing all of the desirable qualities of tin. It is conceivable that research in this connection may develop entirely satisfactory substitutes which may permanently replace tin for certain purposes.

3. Curtailment, for the time being, of certain lines of manufacture, not absolutely essential to the prosecution of the war.

Efforts along all of the above-mentioned lines are being made in practically all tin-consuming industries, and much progress has been made. In considering the details of tin conservation, it is my intention to confine myself to a brief discussion of this subject as related to the tin- and terne-plate industry.

Terne-plate is a mild-steel sheet coated with an alloy of tin and lead (approximately 25 per cent tin and 75 per cent lead). Its chief uses, in normal times, are for roofing, gasoline and oil tanks, and for stamping into various forms. Manufacturers of this material have almost entirely discontinued its manufacture, except to supply the urgent needs of the Government for war purposes.

It has been customary to use a small amount of tin with the spelter in the galvanizing pots in the manufacture of galvanized sheets. It has been found that, by a sacrifice of no other quality than appearance, this tin could be omitted, and the practice has been largely discontinued—entirely so in the concern with which the writer is connected.

Tin-plate consists of thinly rolled mild-steel sheets coated with pure tin, and its chief use is in the canned-

food industry. The Government has requested that the manufacturers of this product give absolute priority to orders covering material to be used for the manufacture of plate for cans to contain perishable foods. The manufacturer has, of course, complied with this request and the conditions of the markets have been such that almost the entire capacity of the country has been utilized for such material, and for other direct and indirect Government needs.

Several grades of tin-plate are regularly manufactured, differing only in thickness of the tin coating. While for some few uses the heavier coated sheets are desirable and necessary, it is a fact that the most lightly coated sheets are entirely suitable for a very large percentage of these requirements. It is in this connection that the consumer can materially aid in the saving of tin during the present stringency, and also prevent a serious economic waste in normal times, by not specifying a heavier coated plate than his requirements justify.

For years it was believed by certain canners, manufacturers, and dealers in canned goods, that a heavy tin coating was necessary on food containers. This opinion was endorsed by food officials and chemists, and attempts have been made in Congress to regulate the weight of tin coating. Since the literature on the subject gave no definite information, a committee was formed several years ago, consisting of representatives of the American Sheet and Tin Plate, American Can, and the National Canners' Association two representatives of the Bureau of Chemistry, Department of Agriculture, also participated in the work. This committee prepared seven lots of tin-plate with the following average coatings, expressed in pounds of tin per base box (112 sheets, 14 by 20 in.).

A	0.9 lb.	E	1.8 lb.
B	1.1 lb.	F	2.1 lb.
C	1.3 lb.	G	3.0 lb.
D	1.5 lb.		

Cans were made from these plates in the usual way, and various food products were packed under the supervision of the committee, in regular canning plants.

The cans and contents were inspected and analyzed from time to time, throughout a period of about 18 months after filling the cans. In this work more than 40,000 samples were analyzed chemically. I quote from the general conclusions of this committee as embodied in their report:

"The most significant fact established by this entire investigation is that, aside from the external appearance of the cans, none of the difficulties encountered in the twenty experimental packs of twelve representative foods in plain cans was taken care of or eliminated by heavy tin coatings. . . . The luster and the resistance to rusting increase somewhat with increased weights of coating. In other respects, with the exception of some instances in those classes of foods that have a tendency to perforate, the conclusion from this work is that the value of different weights of tin coating on food containers is for all practical purposes the same with average weights of from one to three pounds of tin per base box."

I bring this investigation to your attention to emphasize the needless waste attendent upon the use of tin plate with an unnecessarily heavy tin coating. With our present knowledge, we are unable commercially to produce coatings as light as the lower weights used in this test. If, however, future research should develop means to this end, the resultant product would meet all practical requirements, and a very considerable saving in pig tin would result.

The Bureau of Standards Investigations

Dr. Paul D. Merica presented the paper by Messrs. G. K. Burgess and R. W. Woodward, from which the following are extracts:

"There is no question but that the tin content of nearly all bearing metals can be reduced to some extent, and in some cases actually eliminated without prejudice to the service rendered. So the problem is to determine what needs are the most exacting, or when a breakdown would cause the greatest damage and confine the use of high tin babbitts to these uses only. Thus the main bearings of airplane and military automobile engines, turbine shafts, etc., will probably have to continue to use high tin babbitt with a tin content of from 84 per cent to 91 per cent. A babbitt metal such as S. A. E. specification No. 24 containing 84 tin, 9 antimony and 7 copper appears to be as satisfactory in service as one such as genuine babbitt, 89 tin, 7½ antimony, 3½ copper, or that specified by the International Aircraft Standards Board, 91 tin, 4½ antimony, and 4½ copper; but it should be pointed out that the latter two compositions are more fluid in the molten condition than the first named and consequently the lining can be made in a thinner shell with these babbitts and the total amount of tin consumed may therefore be less than if the S. A. E. No. 24 was used. However, if the design of the bearing is not altered to admit of the thinner shell, the lower composition babbitt should be used in general.

The following compositions are also recommended for use where a high grade of lining is required and when a genuine babbitt is often now used:

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Tin	65	62	8	5	10.0	21.3
Antimony	.....	.....	8	7	12.5	.....
Copper	3 to 6	4	4	2	0.5	3.0
Zinc	28 to 30	33	..	76	....	63.3
Aluminium	.....	1				
Lead	.....	..	80	10	77.0	12.0

Nos. 3 and 4 have been found to do the service required of tin base linings in machine tool bearings; No. 5 can be used on similar bearings where a greater strain is met. No. 6 is in use in Germany as a "best" babbitt to conserve both tin and copper.

For linings on railroad truck journals two compositions are in general use, one composed of 85 lead, 10 antimony, 5 tin, and the other of 87 lead and 13 antimony. The latter is restricted by some roads to freight service and the former used on passenger equipment. Many roads, however, use the 87 lead and 13 antimony on both classes of service and it seems that its use might be made more universal.

Another type of lining metal which deserves serious consideration is one composed almost entirely of lead with small additions of alkali or alkali earth metal. Certain of these have been given service tests at the Bureau of Standards and in many respects were found equal to or superior to genuine babbitt.

Following is a summary of the tests on the metal and

similar tests on genuine babbitt of composition 89 tin, 7½ antimony, 3½ copper:

GENUINE BABBITT

Lead, Lb. per Sq.In.	R. P. M.	Total No. of Revolutions	Final Temp. °C.	Final Temp. °F.	Rise in Temp. °C.	Rise in Temp. °F.	Friction Lb.	Loss in Weight Gram	Remarks
100	694	12,230	89	192	53	95	22	0.023	
200	706	16,510	102	216	58	104	29	0.021	
300	682	15,150	125	257	100	180	38	0.013	Belt slipping
400	603	6,600	139	282	94	169	79	0.054	Bearing seized and smoking

ULCO HARD METAL

100	710	13,160	56	133	23	41	13	0.013	
200	715	18,870	69	156	33	59	18	0.021	
300	719	18,830	80	176	42	76	27	0.013	
400	711	17,310	81	178	43	77	23	0.022	
500	723	17,660	79	174	43	77	25	0.014	
600	692	14,960	84	183	45	81	24	0.021	
700	648	24,520	62	144	38	68	24	0.020	
800	365	12,870	53	127	20	36	23	0.010	
900	408	22,300	59	138	22	40	24	0.015	
1000	405	23,200	66	151	36	65	22	0.014	Bearing still good condition.

Standard Grades of Babbitt Metal

At a meeting called by the Conservation Division of the War Industries Board on April 15, 1918, which was attended by manufacturers and users of bearing metals, the Bureau of Standards was requested after conference with technical representatives of the large manufacturers and users, to determine if four classes of babbitt metal could be adopted ranging in tin content as follows:

A—Genuine babbitt, 89 per cent tin.

B—Genuine babbitt, 40 to 50 per cent tin.

C—Genuine babbitt, 4 to 6½ per cent tin.

D—Genuine babbitt, no tin.

The bureau has gone over the situation with several of the representatives and the general opinion seems to be that it is impossible to limit some of the classes to a single composition, because of the fact that several compositions of nearly the same tin content are in general use for different purposes. Thus in the table below No. A1 is used in aircraft engines, No. A3 is used for automobile engines, No. A4 is found in bearings of electrical machinery. It was thought, however, that class B can be entirely dispensed with, as these intermediate tin content bearing metals are in no way as satisfactory as either a high lead or high tin base babbitt. In all cases where class B could be used, class C or class D will be found to serve the purpose equally as well. There are, however, some grades of babbitt containing about 65 per cent of tin which do not fall into either class A or class B, but which are often claimed by the manufacturers to equal the high tin babbitt in performance. If these claims can be substantiated this babbitt should be considered as falling into the category of class A and as being a substitute for alloys in that class.

It should not be presumed, because high tin babbitt of class A is included, that the bureau recommends the continuance of its use for many bearings in which it is now used. The lowest possible tin content alloy should always be used, and the bureau believes that it might be advisable to leave some central body issue license for the use of babbitt in class A in order to insure that no class A babbitt is being used where others are satisfactory.

Alloy D2 has been included in class D because this comprises babbitt metals containing no tin. It should be noted, though, that this alloy will be found satisfactory in many installations where class A has hitherto been used and its inclusion in class D should not give the impression that it is a low grade babbitt.

The American Society for Testing Metals has drawn up specifications for twelve compositions of babbitt metals (B23-18T) which, however do not take into consideration the factor of tin conservation, but are formed for use in peace times. The present recommendations are for use in the existing situation, where the saving of all tin possible is of prime importance.

The recommended compositions for the various classes are given in the table below. These compositions have been selected so as to include existing specifications and usage of babbitt metals as far as possible. Much information has been secured from the questionnaire sent cut by the bureau and from replies to the general letter issued by the War Industries Board on May 29, 1918.

Class	No.	Tin Per Cent.	Antimony, Per Cent.	Lead, Per Cent.	Copper, Per Cent.	Iron, Max.	Arsenic, Max.
A	A 1	91	4½	1.00 a	4½	0.08	0.10
	A 2	89	7½	1.00 a	3½	0.08	0.10
	A 3	84	9	1.00 a	7	0.08	0.10
	A 4	83	8½	1.00	8½	0.08	0.10
C	C 1	5	10	85	0.50 a	....	0.20
D	D 1	..	13	37	0.50 a	....	0.25
..	D 2	Lead about 98%, balance alkali and for alkali earth.					

a Maximum.

More than traces of impurities other than those listed above will not be allowed; the following variations above or below the specified amount will be permissible for the desired elements:

Percentage of Elements Specified	Permissible Variations Over or Under the Specified Value Units of per Cent.
Not over 5 per cent.	0.50
5 to 10 per cent, incl.	0.75
Over 10 per cent.	1.00

Large quantities of phosphor bronze of the compositions 80 copper, 10 lead, and 10 tin are dioxidized with phosphorus, are used in unlined bearings at fairly high speeds and pressures. The following compositions have been suggested as substitutes for phosphor bronze, although it is our opinion that trouble will sometimes be experienced with Nos. 8, 9 and 10, because of the high lead content, although they have about the same tin content as the others in the list.

	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
Copper	81	79	74	64	Remainder	Remainder
Tin	7	5	5	5	8	5
Lead	9	15	20	25	15	17.5
Zinc	3	...	...	...	1.5–3.0	5.0
Antimony	..	..	..	5	.....	.....
Phosphor Copper	..	1	1	1	.....	.....

Structural Bronzes

Passing now to the bronzes other than those for bearing purposes, we find that "Government Bronze" (Navy Specification, 46M6a, Gun Metal) or 88 copper, 10 tin, and 2 zinc, is used in large quantities and can also be modified to admit of a saving of tin without impairment of the physical properties sought. Experiments by the Bureau of Standards and others have shown that a composition of 88 copper, 8 tin, and 4 zinc, is equal to or superior to the ordinary Government bronze. Aluminium bronze of composition 90 aluminium, 10 copper, for example, can also be substituted for many uses of Government bronze, as can also manganese bronze and naval brass. There have also been introduced several aluminium bronzes containing small amounts of iron, which can be either cast or wrought, and which are now being used by several former users of Government bronze.

Some manufacturers have raised an objection to using aluminium bronze because the scrap accumulating from this alloy, if it gets mixed with other metals, particularly value metals, would have a deleterious effect upon them. This is simply a problem in works management of properly sorting and routing scrap. We know of several large manufacturers who make aliminium bronze castings in the proximity of steam metal castings and who by taking the proper precautions have encountered no difficulties.

The following table gives some of the properties of the above mentioned alloys:

Alloy	Tensile Strength Lb. Sq.In.	Elastic Limit Lb. Sq.In.	Elongation in 2 In. Per Cent.	Authority
Government bronze 88 Cu 10 Sn, 2 Zn....	38,860	12,250	25.2	Average of 30 tensile specimens poured in 5 different foundries. Tensile tests made at the Bureau of Standards.
88 Cu, 8 Sn, 4 Zn	39,220	11,000	30.6	Same as above, except that it only represents 26 specimens.
Aluminium bronze	71,000	25,000	21	Corse & Comstock Trans.Soc.Autom. Eng., 1916, part II p. 272-73.
Manganese bronze, U.S.N., Mn...	70,000	35,000	30	Navy Department Specification 46-B15.
Naval brass....	54,000 over 1 in. 60,000 below ½ in.	25,000	40	Navy Department specification 46B-6b.
Aluminium bronze with iron (Sillman bronze):				
Wrought alloy	84,400	14,000	11.5	Bureau of Standards Test.
Cast Alloy....	78,850	11,500	14.5	
Chemical composition Cu				86.4 per cent.
Chemical composition Al				9.7 per cent.
Chemical composition Fe				3.9 per cent.

Cadmium as Tin Substitute in Solder

Cadmium appears as a promising substitute for part of the tin in solders. The bureau has been developing such a solder, and laboratory test together with manufacturing experience so far point to a composition of 80 lead, 10 tin and 10 cadmium as being practical for many of the purposes for which solder is required. This solder has been tried in the manufacture of tin cans, on roofing materials, and for electrical joints with encouraging results in all cases. Before using it for food containers, however, it will be necessary to ascertain its toxic properties under various conditions. A test has also been made of it in the manufacture of automobile radiators with most satisfactory results.

The tensile strength of the cadmium solder is about the same as that of 40-60 solder, but the ductility is approximately twice that of the ordinary solders. The point of complete liquation is only slightly higher than that of the ordinary composition of solders, while the range of solidification is considerably greater. Table I gives some of the provisional data on these solders as compared to the tin-lead solders; the tensile properties given are the average of four determinations and even made on a Scott testing machine, the rate of separation being about twelve inches per minute.

Because of the preponderance of lead in the cadmium solder, the price of it is very reasonable; with the present market prices of the metals involved it is thought that the 80-10-10 solder can be sold at a profit at 35 cents a pound. It is also thought that plenty of cadmium can be produced as soon as the market of it is created as there are undoubtedly available American sources of cadmium which are not at present exploited.[1]

In meetings with manufacturers of materials containing tin it is always brought out that the Government is the worst offender, and that many Government specifications often call for a lavish use of tin which is sometimes detrimental to the quality of the material manufactured. We believe, however, that many of these specifications are being revised in order to conserve tin, but that there is still room for further improvement. As a means of conserving the use of tin by the Government, we would suggest the advisability of creating a joint committee of technical representatives of the various departments to pass upon or revise all Government specifications containing tin. Such a committee could be in close co-operation with the manufacturers and would form a better means for the manufacturers to criticise the tin content of Government specifications than now exists in any of the departments.

TABLE I. PHYSICAL PROPERTIES OF CADMIUM-LEAD AND TIN-LEAD SOLDERS

	Initial Solidification, Deg. C.	Secondary Solidification, Deg. F.	Final Solidification, Deg. C.	Specific Gravity	Equivalent Volume to 1 Volume, 50-50 Solders	Tensile Strength, Lb. per Sq.In.	Elongation, Per Cent
50 tin-50 lead	210*	181*	149*	8.81	1	5,698	20.3
40 tin-60 lead	238*	181*	149*	9.47	1.07	5,820	26.0
37½ tin-62½ lead	245*	181*	149*	9.54	1.08	5,383	28.8
90 lead-10 cadmium	267 ♣	...	249*	11.09	1.26	5,000	37.5
80 lead-10 cadmium-10 tin	254	183	143	10.35	1.17	5,727	52.3
85 lead-10 cadmium-5 tin	257	202	141	10.67	1.21	Not determined	
75 lead-10 cadmium-15 tin	Not determined ...			10.26	1.16	5,880	41.7

* Rosenhain and Tucker, Phil. Trans., A. 209, 1918, p. 89.
♣ Kapp, Drudes Ann., 6 754 (1901).

Other Topics in Brief

Mr. J. L. Jones of the Westinghouse Electric & Manufacturing Co. stated that his company had found that a lead based babbitt of 78 per cent lead, 14 antimony and 8 tin was suitable for all types of electrical machinery. This alloy has a Brinnell hardness of 27 to 28, pours well and is tough and clean. Great care must be taken in its preparation to prevent segregation etc. Furthermore many babbitt linings are being made $\frac{3}{16}$ inch in place of $\frac{3}{8}$ inch. He described a special solder pot for melting babbitt metal which his company has found very advantageous, in that a complete separation of the accompanying oxides is obtained, making clean castings as well as economizing materials.

Mr. W. M. Corse of the Titanium Bronze Co. gave an excellent paper on aluminium bronze which pointed out the excellence of this type of alloy. This paper will be published separately in the near future.

Mr. H. D. Egbert of the Research Corporation pointed out the applicability of electric dust precipitation of the tin vapors at the sash weight foundry cupolas, where old tin cans, etc., are melted up. The development of this field promises a very important recovery, as there need not be a very great expenditure in cleaning off labels etc., from the cans, which can be crushed, dried and smelted.

[1] See C. E. Liebenthal, Cadmium in 1917, Mineral Reserves of U. S., 1917, Part I, 49-53.

Calculation of Extraction in Continuous Agitation

Derivation of a Mathematical Formula for Continuous Systems of Extraction in Hydrometallurgy and Industrial Chemistry — Examples of Application — Modifications for Non-Homogeneous Material and Where Complete Reaction is Required

BY ANDREW HAM AND HARRISON STREETER COE

EDITOR'S NOTE.—The accompanying article has for its basis a paper offered for publication by Mr. Andrew Ham on the mathematical relation between the efficiency of continous and intermittent agitation.

The deductions seemed to be of unquestionable value, but the mode of presentation, which included the derivation of the formula by calculus, seemed somewhat too intricate. With Mr. Ham's approval we invited the cooperation of Mr. H. S. Coe, who confirmed the correctness of the premises and the computations. He has also presented the formula in a different manner, with Mr. Ham's tables modified to be directly applicable in designing continuous agitation plants and determining the losses to be expected therefrom. Mr. Coe further discusses various features not touched on by Mr. Ham and gives a method for making simple tests which will show the relation between continuous and intermittent agitation of ores containing difficultly treated fine sand.

For those desiring to follow the derivation of the formula, Mr. Ham's calculations are appended.

INTRODUCTION

IN THE fields of hydrometallurgy and industrial chemistry, wherever chemical reactions are accelerated by mechanical agitation, the tendency, during recent years, has been to replace the primitive intermittent charge-agitation method by continuous agitation.

Economy of operation has been the principal incentive to this change; and where the nature of the reactions permit, it is generally conceded that continuous agitation has a tremendous advantage over the old method. No one, as far as we are aware, has thus far made public any exact analysis of what physically occurs in a continuous-agitation system, so that treatment by this method can be compared to that in an intermittent-agitation tank. A formula for doing this has been derived by Mr. Andrew Ham and is submitted and explained in Part I of this article.

The method presented for applying the formula differs from that offered by Mr. Ham, but otherwise Part I of this article is a presentation of his formula explained as simply as possible. It follows his own reasoning quite closely, eliminating the somewhat involved mathematical derivation, which is given at the end of the article.

In Part II Mr. Coe offers a discussion of the application of the formula and of some features which modify its use. Conclusions are drawn relative to the use of the formula.

I. DERIVATION AND EXPLANATION OF FORMULA

In general, the difference between the operation of intermittent and continuous agitation may be stated as follows: Whereas in the former method the vessel in which a process takes place has to be filled (and closed under special conditions where heat, pressure, etc., are required) and later emptied at the completion of the treatment, the continuous-agitation system provides a series of vessels (or sometimes only one) in which the material to be treated enters and leaves the system in an uninterrupted stream or at regular intervals. The essential difference in the treatment is that in continuous agitation new material is mixed with material which already has been subjected for some time to the process. Different parts of the material are thus in different stages of treatment, or of different "age," and the material passing out of the system comprises particles which have been subjected to agitation for different periods of time.

It is to determine this "detention" or treatment period which different percentages of the material have had on leaving a continuous-agitation system that the formula given hereafter has been derived.

To establish the formula, a small part of the material which enters a continuous-agitation system in a negligible interval of time is considered; and the proportion of this part remaining in the system after the lapse of any given interval of time is determined.

The small part is called a_0. The quantities v_1, v_2, v_3, etc., represent the fractions of a_0 remaining in the first vessel, second vessel, third vessel, etc., of the system after an interval of time T rated from the entrance of a_0 into the first vessel.

V_1, V_2, V_3, etc., represent the fractions of a_0 remaining in the first vessel, first two vessels, first three vessels, etc.; and if the total number of vessels in the continuous-agitation system be n, V_n represents the fraction of a_0 remaining in the whole system after time T; i.e., the fraction of a_0 which has been treated for time T.

It will be noted that $V_1 = v_1$ (and where $n = 1$, $V_n = V_1 = v_1$), $V_2 = v_1 + v_2$, $V_3 = v_1 + v_2 + v_3$, and $V_n = v_1 + v_2 + v_3 \ldots + v_n$. Since every portion of the entering material has the same experience in passing through the system, the numerical values of v_1, v_2, v_3 etc. and V_1, V_2, V_3 etc. apply to all of the material agitated. Thus, if T is 1 hour and v_1 is 0.5 and v_2 is 0.1, V_2 will be 0.6 which means that 50 per cent of the material entering the continuous-agitation system receives 1 hour of agitation in the first vessel and 60 per cent receives 1 hour of agitation in the first two vessels. If the continuous-agitation system contains only two vessels, V_2 will be V_n. The v_2 or 10 per cent found in the second vessel is made up of particles which have received part of their treatment in the first and part in the second vessel, each with a total of 1 hour of agitation.

With all vessels of equal volume in the continuous agitation system the formula for v_1, v_2, v_3 is $v_1 = e^{-zT}$, $v_2 = \frac{zT}{1} e^{-zT}$, $v_3 = \frac{z^2T^2}{2} e^{-zT}$. The general formula is

$$v_n = \frac{z^{n-1}T^{n-1}}{1.2.3.\ldots.(n\text{-}1)} e^{-zT}$$

where n is greater than 1. In this formula $e = 2.71828$ (the natural base of logarithms), z depends on the size of the vessels and the rate of inflow of the substance and is equal to $\frac{\text{rate of inflow}}{\text{capacity of vessel}} = \frac{1}{\text{time to fill the vessel}}$ or $\frac{R}{C}$ where R = rate of inflow and C = capacity of vessel.

Since $V_n = v_1 + v_2 + v_3 + \ldots v_n$, we have, by giving v_1, v_2, v_3 etc., their proper value, the general value for V_n which is,

$$V_n = e^{-zT}\left(1zt + \frac{z^2t^2}{2} + \ldots \frac{z^{n-1}T^{n-1}}{1.2.3.\ldots.(n\text{-}1)}\right).$$

Values of V_n from V_1 to V_7 are given in Table I, for varying values of zT and will help to analyze the treatment received in continuous-agitation systems of from 1 to 7 tanks.

Mr. Coe has added column B to facilitate the use of the table.

In column zT, z is assumed to be a constant for the problem considered, such that the inflowing material just fills one tank in the continuous-agitation system in the time required to treat it by intermittent agitation; zT therefore becomes $\frac{\text{time agitated}}{\text{time required}}$ This column helps to compare directly the treatment in an intermittent-agitation tank with that in continuous-agitation systems comprising tanks of the same size as the intermittent-agitation tank; and as hereafter shown may be used indirectly in comparing treatment in an intermittent-agitation tank with continuous agitation systems made up of tanks of other sizes.

In column B, T is taken as a constant for the problem considered; T being a given required period of agitation by intermittent agitation. In this case, RT, the quantity of material entering the continuous-agitation system in time T, equals the volume of an intermittent-agitation tank required to treat RT units of material in time T. The numerical values given in column B represent the ratio between the size of each tank in a continuous-agitation system and that of the required intermittent-agitation tank to treat the same quantity of material (assuming the latter to work without lost time, which is of course impossible).

Examples of Use of Table

If we consider a homogeneous substance to be treated we may compare the size of tanks in the continuous-agitation systems necessary to give required results, to that of an intermittent-agitation tank doing the same work.

Example 1. Let us say arbitrarily that 98 per cent of the material must be agitated for the full period of time required by intermittent agitation.

In column B of the table, T is assumed to be this full period, and we may note that

In a continuous-agitation system where V_1 = .98, B = 50.0
In a continuous-agitation system where V_2 = .98, B = 1.0
In a continuous-agitation system where V_7 = .98, B = 0.379 (by interpolation)

In other words, to give full treatment to 98 per cent of the material by continuous agitation requires a continuous-agitation tank 50 times as large, a four-tank continuous-agitation system with each tank of the same volume, a seven-tank continuous-agitation system with each tank of 0.379 the volume of the required intermittent-agitation tank.

Example 2. Comparison of treatment in a three-tank continuous-agitation system with that in an intermittent-agitation tank of the same volume as each continuous-agitation tank and treating the same quantity as the continuous-agitation system. In column A of the table the fractions of the total treatment period are given and in column V_3 the fractions of the material receiving these fractions of the treatment period are shown.

Thus 0.999 remains in the continuous-agitation system for 0.2 full periods
0.977 remains in the continuous-agitation system for 0.6 full periods
0.920 remains in the continuous-agitation system for 1.0 full periods
0.809 remains in the continuous-agitation system for 1.5 full periods

The fraction of the total soluble substance dissolved during the passage of the material through the continuous-agitation system is as follows:

Between 1.000 and 0.999 of total soluble by agitation between 0 and 0.2 full periods
+ Between 0.999 and 0.977 of total soluble by agitation between 0.2 and 0.6 full periods
+ Between 0.977 and 0.920 of total soluble by agitation between 0.6 and 1.0 full periods
+ Between 0.920 and 0.809 of total soluble by agitation between 1.0 and 1.5 full periods

By taking the fractions of the agitation period closely together, a close estimate of the fraction of the total solubles dissolved may be reached.

Example 3. Comparison as in example 2 where the continuous-agitation tanks are not equal in volume to the intermittent-agitation tank required.

In this case multiply the numerical value given in column zT by the ratio,

$$\frac{\text{volume of tank in continuous agitation system}}{\text{volume of intermittent agitation tank}},$$

Thus if we are comparing a continuous-agitation system where the volume of each tank equals one-half the volume of the required intermittent-agitation tank the fraction of the treatment period given in column zT must be multiplied by one-half and the results for a three-tank continuous-agitation system would be

0.999 remaining in system for 0.1 full periods
0.977 remaining in system for 0.3 full periods
0.920 remaining in system for 0.5 full periods
0.809 remaining in system for 0.75 full periods
0.676 remaining in system for 1.00 full periods
0.423 remaining in system for 1.50 full periods

The fraction of the total soluble substance dissolved during the treatment should be:

Between 1.00 and 0.999 of total soluble by agitation between 0 and 0.1 full periods
+ Between 0.999 and 0.977 of total soluble by agitation between 0.1 and 0.3 full periods
+ Between 0.977 and 0.920 of total soluble by agitation between 0.3 and 0.5 full periods
+ Between 0.920 and 0.809 of total soluble by agitation between 0.5 and 0.75 full periods
+ Between 0.809 and 0.676 of total soluble by agitation between 0.75 and 1.00 full periods
+ Between 0.676 and 0.423 of total soluble by agitation between 1.00 and 1.50 full periods

The fractions of substance soluble during the fractional periods indicated are to be taken from extraction tests made by intermittent agitation.

II. Applications of Formula

Mr. Ham's formula applies directly to designing continuous-agitation plants, using laboratory tests by intermittent agitation as a basis, provided the material to be agitated is homogeneous; i.e., uniform in size and weight of particles, and if the solvent is maintained at practically the initial strength throughout the treatment.

Where the solids to be agitated contain particles of varying size and weight the use of the formula may be changed due to the concentration of coarse material in the tanks of the continuous-agitation system.

In agitators where the contents are kept in violent motion, there is no chance for such concentration and the formula applies directly, since the material as a whole remains homogeneous. In another type of agitation, such as the Dorr, there is abundant opportunity for concentration of the heavier particles, since the material simply settles to the bottom of the tank to be collected and elevated (together with solution) to the surface by means of an air-lift and redistributed over the tank. When operation is started, the first tank acts therefore as a sand trap. The sand collected from the inflowing material increases until an equilibrium is reached; after which the sand in the material passing over to the second tank will be in the same proportion as in that entering the system.

If we assume that the soluble substance most slowly dissolved is in the sand, which is nearly always true, and that the sand in the tanks is concentrated to, let us say, four times its concentration in the inflow, then relative to the sand treatment each Dorr agitator in the system acts as a tank four times as large as would be indicated by its actual volume; except that the sands so concentrated are not continuously treated with the same solution but receive constantly a fresher solution which accompanies the slimy parts of the ore in its more rapid passage through the system. In other words the feed to the system is of one dilution but the agitation proper is effected on a denser pulp with the effect of constantly adding fresh solution.

Thus in example 3, the percentage of soluble substance dissolved would be raised to

Between 1.00 and 0.999 of total substance in sand soluble between 0 and 0.4 full periods
+ Between 0.999 and 0.977 of total substance in sand soluble between 0.4 and 1.2 full periods
+ Between 0.977 and 0.920 of total substance in sand soluble between 1.2 and 2.0 full periods.

With tanks each one-half the size of the intermittent-agitation tank required showing such complete treatment, it appears quite probable that the total volume in the continuous-agitation system might be equal to or less than that of the required intermittent-agitation tank and yet give better extraction than the latter. Results from practice confirm this view.

Modification Necessary in Special Cases

Another case where it seems necessary to modify the use of the formula is where a complete reaction is required in the system, the solution to be neutralized as well as the substance to be dissolved. The strength of solution in each tank may be computed from the table, provided the rate of reaction of solution of blended strengths on blended fresh and partly treated material is the same as when the relative fractions of the solution and material are agitated alone. It would appear that a relation between these rates might be established by laboratory tests, and Mr. Ham's formula would then become useful for this case.

Conclusions

From the foregoing explanation and the treatment features noted in Part II it is Mr. Coe's conclusion that Mr. Ham's formula is directly applicable in a limited number of instances but that its chief value lies in the fact that it gives a method to study the history of the material in passing through a continuous-agitation system.

When its use is modified to conform to conditions above noted it should be of distinct value in designing continuous-agitation plants. It also affords a starting point for estimating the relative merits of various continuous-agitation systems and for determining whether continuous agitation is suitable to the reaction under consideration.

TABLE I

Computed by formula $Vn = e^{-zt}\left(1 + zt + \tfrac{1}{2}z^2t^2 + \cdots \frac{1}{1.2.3\ldots(n-1)}\right)(zt)^{n-1}$

		Value of Vn from V_1 to V_7						
B	ZT	V_1	V_2	V_3	V_4	V_5	V_6	V_7
200.00	0.005	0.995	0.9999	1.000	1.000	1.000	1.000	1.000
100.00	0.010	0.990	0.9999	1.000	1.000	1.000	1.000	1.000
66.67	0.015	0.985	0.9999	1.000	1.000	1.000	1.000	1.000
50.00	0.020	0.980	0.9999	1.000	1.000	1.000	1.000	1.000
40.00	0.025	0.975	0.9998	1.000	1.000	1.000	1.000	1.000
33.33	0.030	0.971	0.9996	1.000	1.000	1.000	1.000	1.000
25.00	0.04	0.962	0.9992	1.000	1.000	1.000	1.000	1.000
20.00	0.05	0.951	0.999	1.000	1.000	1.000	1.000	1.000
16.67	0.06	0.942	0.998	1.000	1.000	1.000	1.000	1.000
14.28	0.07	0.932	0.997	1.000	1.000	1.000	1.000	1.000
12.50	0.08	0.923	0.997	1.000	1.000	1.000	1.000	1.000
11.11	0.09	0.914	0.996	1.000	1.000	1.000	1.000	1.000
10.00	0.10	0.905	0.995	1.000	1.000	1.000	1.000	1.000
6.67	0.15	0.861	0.991	1.000	1.000	1.000	1.000	1.000
5.0	0.20	0.819	0.983	0.999	1.000	1.000	1.000	1.000
4.0	0.25	0.780	0.974	0.998	1.000	1.000	1.000	1.000
3.3	0.30	0.741	0.963	0.996	1.000	1.000	1.000	1.000
2.50	0.40	0.670	0.938	0.992	0.999	1.000	1.000	1.000
2.0	0.50	0.607	0.910	0.985	0.998	1.000	1.000	1.000
1.67	0.60	0.549	0.879	0.977	0.997	1.000	1.000	1.000
1.43	0.70	0.497	0.844	0.961	0.989	0.999	1.000	1.000
1.25	0.80	0.449	0.809	0.952	0.991	0.998	1.000	1.000
1.11	0.90	0.407	0.772	0.937	0.986	0.998	0.999	1.000
1.00	1.00	0.368	0.736	0.920	0.980	0.996	0.998	1.000
0.911	1.10	0.333	0.699	0.900	0.974	0.994	0.998	0.999
0.833	1.20	0.301	0.663	0.878	0.965	0.992	0.998	0.999
0.769	1.30	0.273	0.627	0.857	0.957	0.989	0.998	0.999
0.666	1.50	0.224	0.558	0.809	0.935	0.982	0.995	0.999
0.588	1.70	0.183	0.493	0.757	0.907	0.970	0.991	0.997
0.500	2.00	0.135	0.406	0.676	0.857	0.947	0.982	0.995
0.400	2.50	0.082	0.287	0.544	0.758	0.890	0.957	0.986
0.333	3.00	0.050	0.199	0.423	0.646	0.815	0.916	0.966
0.285	3.50	0.030	0.136	0.320	0.536	0.724	0.857	0.933
0.250	4.00	0.018	0.092	0.238	0.415	0.611	0.768	0.871
0.222	4.50	0.011	0.061	0.173	0.342	0.532	0.703	0.832
0.200	5.00	0.007	0.040	0.124	0.265	0.410	0.616	0.762
0.167	6.00	0.002	0.017	0.062	0.151	0.285	0.446	0.606
0.143	7.00	0.001	0.007	0.028	0.080	0.171	0.299	0.448
0.125	8.00	.....	0.003	0.014	0.042	0.100	0.188	0.310
0.111	9.00	.....	0.001	0.006	0.021	0.055	0.116	0.207
0.100	10.00	.....	.....	0.004	0.010	0.029	0.067	0.130
0.091	11.00	.....	.....	0.001	0.005	0.015	0.038	0.079
0.083	12.00	.....	.....	0.001	0.002	0.008	0.020	0.046
0.077	13.00	.....	.....	.....	0.001	0.004	0.011	0.025
0.071	14.00	.....	.....	.....	.....	0.002	0.005	0.014
0.066	15.00	.....	.....	.....	.....	0.001	0.001	0.008

Derivation of Formula by Andrew Ham

For general explanation see Part I of this article.

Let a_0 = a small quantity of material entering the system during a negligible interval of time.

Let t = time, rated from the entrance of a_0 into the system.

Let R = rate of flow of material into the system and from tank to tank.

Let c = capacity (volume) of each tank in the system.

Let a = the quantity of a_0 remaining in tank No. 1 after time t.

Then $\frac{a}{c}$ = quantity of a_0 in a unit volume of the contents of number 7 tank at any time.

$-R\frac{a}{c}$ = the rate at which a_0 is leaving tank No. 1.

$+\frac{da}{dt}$ = the rate at which a_o is leaving tank No. 1.

$\therefore \frac{da}{dt} = -\frac{Ra}{c}$ or $\frac{1}{a}\,da = -\frac{R}{c}\,dt$.

Let $\frac{R}{c} = z$ (a constant for the problem considered)

Then $\frac{1}{a}\,da = -\,zdt$, $\int \frac{1}{a}\,da = \int -\,zdt$

$\log a = -\,zt + c$ (c = constant of integration)

$$a = e^{(-zt+c)} = (e^{-zt})(e^c)$$

Let $t = o$; then $a = a_o$ and $a_o = (1)\,(e^c)$

$\therefore a = a_o\,e^{-zt}$ or $\frac{a}{a_o} = e^{-zT}$ (I). This is the fraction of a_o in tank No. 1 after any time T. Call this fraction v_1.

CONSIDERATION OF TANK NO. 2

$\frac{da}{dt}$ = rate at which a_o leaves tank No. 1 at time t.

$da = -\,a_o z e^{-zt}dt$ (from (I)).

$-\,da$ = the quantity of a_o entering tank No. 2 during interval dt at time t.

$\frac{da'}{-da}$ = the fraction of $(-da)$ remaining in tank No. 2 after time t_1 rated from the entrance of $(-da)$ at time t.

Hence, by comparison with (I):

$da' = (-\,da)\,e^{-zt} = (a_o z e^{-zt}dt)\,e^{-zt_1}$.

Let $t + t_1 = T$, a constant, the time for which the investigation is being made. Then $t_1 = T - t$ and $da' = a_o z e^{-zT}dt$.

$a' = \int a_o z e^{-zT}dt = a_o z t e^{-zT} + c'$ ($c' = o$ = constant of integration).

$\therefore$ at time T, $a' = a_o z t e^{-zT}$ or $\frac{a'}{a_o} = zTe^{-zT}$ (II). This is the fraction of a_o remaining in tank No. 2 after time T rated from the entrance of a_o into system. Call this fraction, v_2.

CONSIDERATION OF TANK NO. 3

Here we have the condition of a continuous supply of a_o reaching tank No. 2 and also leaving it, whereas in No. 1 a_o arrived all at once.

$-\,da$ enters No. 2 in interval dt and $\frac{da'}{dt}$ (the rate of change in the quantity of a_o in No. 2 is made up of $\left(\frac{-da}{dt}\right)$ and the rate of a_o passing to tank No. 3.

Hence $-\frac{da'}{dt} + \frac{(-da)}{dt} = (a_o z^2 t e^{-zt} - a_o z e^{-zt})$

$= az^2te^{-zt}$ is the rate at which a_o is entering No. 3 at time t.

$-\,(da' + da) = a_o z^2 t e^{-zt}dt$ = quantity of a_o entering No. 3 during dt at time t.

$\frac{da''}{-(da' + da)}$ = fraction of $-(da' + da)$ remaining in No. 3 at time t_1, rated from entrance of $-(da' + da)$.

By comparison with (I):

$da'' = -\,(da' + da)\,e^{-zt_1} = (a_o z^2 t e^{-zt}dt)\,e^{-zT}$.

Again let $T = t + t_1$; then

$da'' = a_o z^2 t e^{-zt}dt$.

$$\int da'' = a'' = \int_{t=o}^{t=T} a_o z^2 t e^{-zt} = a_o \frac{z^2T^2}{2}\,e^{-zT}.$$

$\frac{a''}{a_o} = \frac{z^2T^2}{2}\,e^{-zT}$. (III). This is the fraction of a_o remaining in Tank No. 3 after time T rated from the entrance of a_o into the system. From the above we have $v_1 = e^{-zt}$, $v_2 = e^{-zt}zt$, $v_3 = e^{-zt}\frac{z^2t^2}{2}$. The general expression for v_n (n being greater than 1) is

$$v_n = e^{-zt}\frac{(zt)^{n-1}}{1.2.3.\ldots.(n\text{-}1)}.$$

If we let V_1, V_2, V_3.... V_n be the total fraction of a_o remaining in the first tank; first two tanks, first three tanks....first n tanks, then

$$V_n = e^{-zt}\left(1 + zt + \frac{z^2T^2}{2} + \ldots\ldots\frac{(zt)^{n-1}}{1.2.3.\ldots.(n\text{-}1)}\right).$$

This is the general formula for the fraction of a_o remaining in a system of n tanks after time T, rated from the entrance of a_o into the system.

Importation of Optical Glass Controlled by the Government

The importation into the United States of French optical glass is to be controlled by the Government. American manufacturers and importers desiring this glass must place their orders through the War Industries Board and the War Trade Board. Direct orders will lack the government approval and necessary endorsements to allow the importation.

Regulations for the importation of French optical glass adopted following conferences between the Military Optical Glass and Instruments Section of the War Industries Board, of which George E. Chatillon is chief, and the Bureau of Imports of the War Trade Board, provide:

1. All import orders for French optical glass should be placed with the Service Geographique, who will distribute them among the various French manufacturers.
2. The order, together with the application for import licenses, should be forwarded to the War Trade Board, Bureau of Imports, to the attention of Mr. Reardon.
3. The applications should state in detail the purpose for which the glass is intended.
4. The War Trade Board will in all cases consult with the Military Optical Glass Section of the War Industries Board before applications are granted.
5. Orders placed direct will not have the approval of the Military Optical Glass Section nor the necessary endorsement of the War Trade Board to allow the glass to be imported from France.
6. If glass of a special manufacturer is desired, it may be noted on the order.

Production of Hand Grenades

Major General C. C. Williams, chief of ordnance, has written the Single Service Package Corporation of New York City, commending the employees of that plant for having attained a production speed of more than 100 hand grenades a minute.

The third million of grenades made by this concern was shipped to France the middle of last month, having been produced in exactly one month's time. During the week ending September 14, the plant shipped a total of more than 300,000, or 55,000 a day, Saturday being counted as four-ninths of a day, and this despite the fact that the plant was closed down ahead of time September 12 to permit employees to register under the Selective Service draft act. The maximum production was attained Friday, September 13, when 55,200 grenades were turned out. Simple as a completed grenade seems, it requires twenty-five distinct operations.

Commercial Uses of Chlorine*

A Review of the Direct and Indirect Applications of Chlorine in Independent Uses, Metallurgy, Poisonous Gases, Inorganic Salts and Organic Solvents, Pharmaceuticals and Intermediates

By V. R. KOKATNUR

THE electrolytic manufacture of caustic soda during the last decade or so has brought such new problems to the fore, which if not solved immediately seem to threaten the very life of the industry that has given them birth. The electrolysis of brine produces caustic soda, hydrogen and chlorine. Caustic soda produced by the Solvay Process is decidedly cheaper than electrolytic caustic, while electrolytic chlorine can be made cheaper than chlorine made by other methods.

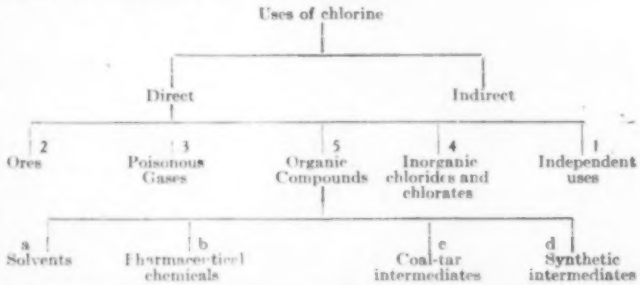
Thus it is easy to see that the success of the electrolytic alkali industry depends not so much upon the profits obtained from caustic as upon those from chlorine. Though the main object in the electrolysis of brine is caustic soda, chlorine thus assumes a greater importance in the electrolytic alkali industry. In other words, the evaluation of the products of electrolysis of brine depends not so much on our motive of electrolysis as on the practical side of the question. Hence chlorine becomes important as a primary-product, since among the products of electrolysis, it is at the same time the most important and the cheapest.

After all, the question whether a product should be called a primary-product or a by-product is settled by its cheapness of manufacture and its utility, and from this standpoint chlorine can be called a primary-product and not a by-product. While hydrogen can be thrown away without much detriment to the neighboring community, chlorine cannot be so dealt with, even if it was so desired, on account of the damage suits such a step might involve. In addition we cannot afford to throw it away since electrolytic caustic cannot successfully compete with Solvay caustic unless its allies, hydrogen and especially chlorine, reinforce and strengthen its ranks.

We are thus confronted with the double necessity of utilizing chlorine, first because we cannot afford to throw it away, and secondly because we cannot throw it away, even if we wanted to, without serious trouble. The unprecedented stimulus given to the chemical industry as a whole by the present war, and its certain growth after the war, will undoubtedly expand the electrolytic alkali industry far beyond its present confines.

Such a growth will result in an enormous production of chlorine. The present consumption of chlorine in the production of bleaching powder or hydrochloric acid cannot further be extended without seriously overflooding the world's markets. Besides it is not profitable. Thus we are confronted with a problem most vital to the life of the alkali industry—a problem which is fraught with grave consequences and pregnant with possibilities; a problem of finding new and profitable uses of chlorine—and if this problem is not solved, it will mean slow but sure death to the industry.

This paper does not claim any originality in its contents. Its main object is to present a systematic treatment of the possible ways of utilizing chlorine, showing the avenues and by-paths. Some of these by-paths show signs of considerable traffic, while others are hardly used and show but few footprints. The known roads are the ones that are followed by many as they offer the least resistance. None but the daring explore the new roads lest they lead them astray to be lost in the wilderness. As in everything else, it is the new road that opens up fields of profitable endeavor and the chlorine industry is no exception.



This table shows the classification of the different ways of possibly utilizing chlorine. Some of these look like footpaths and have a small and limited application, while others appear like beautiful and broad avenues, on which one can travel far and wide, nay, can even cross the continent.

Direct Uses

1. Independent Uses

Among these may be mentioned its use as a bleaching agent in water solution in the textile and paper industries.

It finds use as a disinfectant and sterilizer of potable water, whereby typhoid, cholera and other epidemic diseases are completely eliminated from cities wherever it has been used.

Recently it has been used in the treatment of wounds and their asepsis through what is known as Dakin-Carrel solution.

Liquid chlorine is known to have been used in gas-warfare in producing smoke-screens or clouds.

It can be used in fumigating houses, thus destroying the microbes of plague and other diseases.

It is used in sewage treatment and also in sterilizing raw-hides.

2. Chlorination of Ores

There have been many patents on the chlorination of ores for specific purposes in metallurgy. Here seems

*Read before the American Electro-chemical Society at Atlantic City, N. J., Oct 1, 1918.

to be a vast field, as a large tonnage of chlorine will be consumed, if in any such line it may find application.

It has been used for the separation of gold or silver from base metals and thus finds an indirect application in the metallurgy of gold and silver.

It is also used in separating copper from nickel, *i. e.*, in the metallurgy of both copper and nickel.

It is used in separating tin as tin-tetra-chloride from tinned iron-scrap by what is known as Goldschmidt's Detinning Process.

It finds application in the extraction of valueless ore-residues, which could not be profitably worked out except by the use of chlorine. Thus a low percent-ore can be worked out successfully to advantage by its use and its valuable metal contents be made available for our use.

The chlorination of ores can be extended *ad infinitum* to newer fields of adventure, taking advantage of the volatility of certain chlorides and the action of chlorine on different metals and metallic oxides. Thus perhaps iron-pyrites may be used for iron manufacture and felspars may some day give us our potash and aluminium.

3. POISONOUS GASES

Gas warfare is perhaps the most unforeseen development of the present war and opens up interesting fields. It is interesting to note that more than fifty per cent of the gases known to be used in the present war are chlorine compounds.

Silicon-tetra-chloride ($SiCl_4$) and titanium-tetra-chloride ($TiCl_4$) are used in producing smoke-screens. Chloro-sulphonic acid (SO_3HCl) used in hand-grenades and smokepots. Phosgene ($COCl_2$) is used in shells as an offensive gas. Chloraceton ($CH_2ClCOCH_3$) and trichloro - methyl - chloro - formate ($Cl\text{-}COOCCl_3$) known as superpalite are used in shells as lachrymators. Benzyl-chloride ($C_6H_5\text{-}CH_2Cl$) is used as a tear-gas in shells; chloropicrin or nitrochloroform ($C(No_2)Cl_3$) also as a tear-gas in shells, mustard gas, *i. e.* dichlorodiethyl-sulphide ($(C_2H_4Cl)_2S$), in shells for both offensive and neutralization, diphenylchlorarsene ($(C_6H_5)_2AsCl$) in shells as a "sneezing gas"; pheyl-carbylamine-chloride ($C_6H_5NCCl_2$) in shells as a lachrymator; dichlormethyl-ether ($(CH_2Cl)_2O$) in shells and methyl-chloro-sulphonate (CH_3ClSO_3) in hand-grenades.

Other so-called gases are benzyl-bromide ($C_6H_5CH_2Br$) used in shells, bromaceton ($CH_2BrCOCH_3$) in hand grenades, bromo and dibromoketones like ($CH_2BrCOC_2H_5$), ($CH_3\ CO\ CHBrCH_2Br$) in shells; xylylbromide ($CH_3C_6H_4CH_2Br$) in shells; allylisothio-cyanate (C_3H_5NCS) in shells; dimethylsulphate ($(CH_3)_2SO_4$) in hand grenades, and sulphur-tri-oxide, (SO_3) in hand grenades and shells. It has recently been found that cyanogenchloride (CNCl) and butyl-mercaptan ($C_4H_9\text{-}SH$) are also used.

It will be noticed here that many of these non-chlorine gases are capable of being produced from chloro-compounds, *i. e.*, using chlorine in intermediate steps. For example, allylisothiocyanate can be prepared from allylchloride and potassium sulphocyanate (KCNS); methylsulphate from methyl-alcohol and sulphuryl-chloride; benzyl-bromide from benzyl-chloride and potassium bromide (KBr). Hence it would not be far from truth to say that more than 95 per cent of the poisonous gases can be made directly or indirectly by the use of chlorine.

It is to be regretted that these gases should have been used for incapacitating or destroying human beings, when if intelligently directed they might well serve a useful purpose. There is no reason why they could not be made to save us and our crops from the ravages of microbes and insects, as they are saving us today from the ravages of Prussian militarism. We must not forget that our worst enemies turn out to be our best friends when properly controlled and directed just as some of the worst poisons, like strychnine and morphine, have proven to be.

4. INORGANIC CHLORINE COMPOUNDS

There are many metallic and non-metallic chlorides that have found an extensive application in arts and industries. Chloride of lime or bleaching powder, as it is sometimes called, is used extensively in bleaching, as its name indicates. It is used also in purifying water, as a disinfectant, and in many cases as an oxidizing agent. It is also used advantageously in chlorination of basic substances, like amines, to produce chloramines, and often gives quite different results from ordinary chlorination.

Sulphur-mono-chloride (S_2Cl_2) is used extensively in vulcanizing rubber, making rubber substitutes from oils and fats and preparing the surface of thousands of useful articles. It is also used in deficating cane-juice (sugar refining). It can be advantageously used in the preparation of chlorides free from oxychlorides. It may also find application in preparing organic sulphides.

Sulphuryl-chloride (SO_2Cl_2) and thionyl-chloride ($SOCl_2$) can be used in the preparation of acid chlorides from acid salts and as chlorinating agents. Sulphuryl-chloride can be used in the manufacture from sodium acetate of acetic anhydride, an invaluable ingredient in the manufacture of dyes, cellulose acetate and many other drugs. $4CH_3 - COONa + 2SO_2Cl_2 = 2(CH_3CO)_2O + 2NaCl + Na_2SO_4$.

Phosphorus chlorides such as phosphorous trichloride (PCl_3), phosphorous pentachloride (PCl_5), and phosphoryl or phosphorous oxychloride ($POCl_3$) are all used as chlorinating agents, particularly valuable for the substitution of hydroxyl or oxygen by chlorine. Thus they can be used to prepare ethyl-chloride from alcohol or ether and acid-chlorides from fatty acids.

Antimonytrichloride or butter of antimony ($SbCl_3$) is used as a caustic in medicine, in the preparation of tartar-emetic and as a "bronzing" solution for gun barrels and other instruments. Antimony-pentachloride is often used as a chlorinating agent to serve the purpose of phosphorous chlorides.

Anhydrous aluminium chloride is used extensively in organic synthesis and recently has found application in the "cracking" of petroleum oils to obtain gasolene. Ferric-chloride can be used for similar purposes.

Tin-tetra-chloride ($SnCl_4$) is used in cotton-printing and silk dyeing, while stanous chloride ($SnCl_2$) has an extensive use as a reducing agent. Zinc chloride is used for the impregnation of telegraph poles and railway ties to prevent rot, and also in vulcanizing fiber goods. Zinc oxychloride is used as a cement in dentistry.

Mercuric chloride ($HgCl_2$) and calomel (Hg_2Cl_2) are both used as antiseptics and in medicine. Silver-chlo-

ride in its colloidal form is used extensively in photography. Other chlorides have not yet found industrial application.

Sodiumhypochloride is used extensively in solution for bleaching and as an antiseptic, but if solid sodiumhypochloride could be produced it would be extremely valuable. So far no attempt seems to have been made in this direction, but the day is not far distant when it will be manufactured in large quantities.

Different chlorates like those of sodium, potassium, calcium and barium are used in the manufacture of matches, cartridges, fireworks, dyes and as lozenges for sore throat.

Perchlorates also are being used more and more. Ammoniumperchlorate is perhaps the most economic and at the same time the most terrific of explosives. It is destined to play, in the near future, an important part in industries like mining, especially as there is a great shortage of animal fats, glycerin from which goes to make our dynamites. It is surprising that our government should not have taken any steps in this direction.

5. ORGANIC COMPOUNDS

Chlorine finds an extensive use in various organic compounds as tabulated below under various subheadings.

c. Coal-tar intermediates: Among the most important coal-tar intermediates may be mentioned a derivative of benzene called chlor-benzene, or, as it is sometimes wrongly called, chlor-benzol. It finds an extensive use in the dye industry and in the manufacture of picric acid. Dichlorbenzenes have not so far found any industrial application. It is needless to say that the still higher chlorobenzenes are worse off in this respect. It seems that mono-chlor-benzenes may find application as a solvent, as it can be manufactured cheaply and as it is a more stable compound than aliphatic chlorides, which generally decompose in the presence of moisture and light.

Chlor-toluenes like benzyl-chloride ($C_6H_5CH_2Cl$) can be used to make benzyl-alcohol, which has a good demand in the essential oil industry. Benzol-chloride ($C_6H_5CHCl_2$) is used to manufacture synthetic oil of bitter almonds or benzaldehyde, which is also used in vast quantities in the perfume industry. Benzotrichloride or phenylchloroform (C_6H_5-CCl_3) is used to manufacture benzoic acid. Chlorobenzoic and salicylic acids have a limited application.

Chlorphenols and cresols are used in synthetic work. Recently some chlor-naphthalenes have been used as solvents and in making waxy condensation products for insulation purposes. Chlor-naphthalenes may open up new fields for the dyes of naphthalene series. Chloranalines have a limited application in the dye industry, while chloranil or tetrachlorobenzoquinone has a great demand. The chlorination of anthracene may also open up new fields in the dye industry.

Chlor-acetic acids also are extensively used in dye manufacturing. Monochlor-acetic acid plays an important part in the synthesis of indigo. Dichloracetic acid is used in the synthesis of isatin. Trichloracetic acid is used extensively in medicine.

Phosgene ($COCl_2$) is used in triphenylmethance dyes and in the synthesis of acids and ketones, especially Michaeler's Ketone.

b. Pharmaceutical chemicals: Very little attempt has been made to bring chlorine compounds of pharmaceutical value on the market. In this line chloroform must be mentioned as one being extensively used as an anesthetic. It is also used as an antiseptic and is even used internally in medicine. It is also used in dentistry.

Chloral (CCl_3CHO) finds application as a hypnotic or soporific. Both chloral and chloroform are at present very expensive and a cheaper method of manufacture would be a boon to humanity.

Methylene-chloride finds some use as a local anesthetic. Ethyl-chloride is used also as a local anesthetic, and in conjunction with others in somnoform as a hypnotic. Isopral or trichlorisopropylalcohol (CCl_3-$CHOH\ CH_3$), chloramide or chloralformamide (CCl_3 $CHOH\ NH\ CHO$), chloralimide (CCl_3CHNH) and dormiol ($CCl_3\ CH(OH)O\ C(CH_3)_2\ C_2H_5$) are used in various ways in pharmacy. Ethylene-chloride ($C_2H_4Cl_2$), or "Dutch Liquid," is used as an inhalant and local anesthetic.

Chloretone or acetone-chloroform ($CCl_3(CH_3)_2COH$) is used as a local anesthetic in conjunction with cocaine and adrenaline. Chlor-phenols and cresols are antiseptics of great value, being several times stronger than phenols and cresols and yet are free from their toxic effects. Some chlorinated oils have been tried in Europe for their medicinal value.

Many chlorine compounds like hexachlor-ethane and hexachlor-benzene are likely to be useful either as antiseptics or vermicides, or in both. They may find extensive application in the washing and sterilization of milk cans, as chlorine-solvents are good fat-extractors and antiseptics at the same time.

Dichloramine-T or p-toluene-sulphon-chloramide has been recently used by Drs. Dakin and Carrel in the asepsis of wounds. It is a non-irritating, synthetic germicide and corresponds to the antiseptic chloramine substances that are formed when hypochlorous chlorine is brought in contact with the exudate of suppurating wounds. It can be used in doses twenty to forty times stronger than in hypochlorite solution. It has absolutely no destructive effect on tissue-cells like tincture iodine. It is used also as a nasal antiseptic. It has been found to be better than bleaching powder for the purification of water, because of its stability in solution, non-taxicity, absence of corrosive action and non-production of unpleasant taste.

a. Solvents: The most extensively used chloro-solvent is carbon-tetra-chloride (CCl_4), a compound which is made by the action of chlorine or sulphur-mono-chloride on carbon bisulphide (CS_2). It is used as a solvent in the rubber industry and for the extraction of fats. It is also used in dry-cleaning and in fire-extinguishing mixtures like "Pyrene."

Chloroform ($CHCl_3$) is used to a limited extent as a solvent in electrotechnics in the rubber-industry and in photography. Methylene-chloride, though a good solvent, has not been widely used.

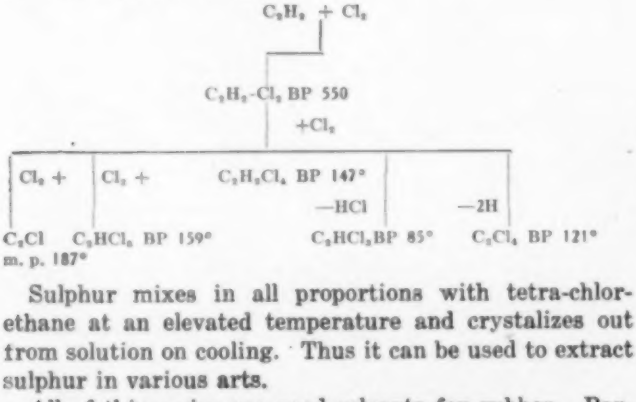
Ethylene-chloride or "Dutch Liquid" ($C_2H_4Cl_2$) is a solvent of great value. It resembles carbon-tetrachloride in most respects and is a good solvent for cellulose acetate. It can be made cheaply by chlorinating ethylene gas obtained by either "cracking" oil gas or by limited hydrogenation of acetylene. Besides being a solvent of great value, it is very useful in the synthesis

of commercially useful chemicals like glycol, a lower homologue of glycerol and malonic acid, which in turn is a reagent of great importance in the synthesis of higher fatty acids by what is known as "malonic acid synthesis."

Glycol-chlorhydrin (CH_2OH-CH_2Cl), another derivative, is a good solvent of both cellulose-acetate and nitrate and is used considerably in the explosive industry. From chlor-hydrins can be prepared solvents called olefin oxides $\begin{matrix} H_2C \\ H_2C \end{matrix}>O$, which are solvents resembling ether. Taurene ($CH_2NH_2CH_2SO_2OH$), a protenoid substance occurring in ox-bile, can be also synthesized from it.

In recent years chlor-ethanes and ethylenes have been extensively used in Europe as solvents in various arts. Among this series of solvents is one made from acetylene and chlorine, called acetylene-tetrachloride, or tetrachlorethane. It is the parent substance of the series of six shown in the diagram below, and is perhaps the best known solvent for cellulose-acetate. As such it is used in making the non-inflammable and non-explosive photographic and motion picture films, and also in the manufacture of "aeroplane dope," i.e., varnish for aeroplane wings.

Pentachlorethane, its higher chlorine derivative, has special properties as a solvent for cellulose-acetate. It plays toward cellulose esters the part that camphor does toward nitro-cellulose. Non-inflammable photographic films of cellulose-acetate containing as high as twelve per cent of acetylene-tetrachloride have been prepared at Rochester. It is known to give certain resilient qualities to the plastic cellulose-acetate that no other solvent is known to give.



Sulphur mixes in all proportions with tetra-chlorethane at an elevated temperature and crystalizes out from solution on cooling. Thus it can be used to extract sulphur in various arts.

All of this series are good solvents for rubber. Particularly so is dichloro-ethylene, which was found to be the best solvent for crude caoutchouc by Emil Fischer. It is thus used in making insulating varnishes and also in the extraction of perfumes from flowers. No better solvent than trichloro-ethylene can be found for the extraction of fat. It extracts fat from dry or moist material and whether in a liquid or a vapor form. It is just as efficient as ether and entails but little loss by evaporation. It has the advantage over carbon-tetrachloride in that it boils about twelve degrees higher; has a lower specific gravity and consequently requires less alcohol and leaves smaller amounts of the solvent on the filter. Further, while carbon-tetra-chloride in the presence of moisture attacks iron vessels, trichloro-ethylene does so very little. With its freezing point as low as —79° C., its boiling point a little higher and being less corrosive on metals, it forms an ideal fire-extinguisher.

Tetra-chloro-ethylene is an ideal dry-cleaning solvent. The solvent power of tetra-chlorethane in the case of fats, resins and waxes is believed to be superior to that of carbon-tetra-chloride. Thus it has been used in the manufacture of paints and varnishes, in boot and metal polishes, in furniture cream, as a paint remover and in cleaning printing rollers and lithographic stones. It does not affect even the most delicate shades and thus can be used in the manufacture of white enamels and paints.

These solvents offer great advantages over other known solvents, as they have a wide range of boiling points and solvent powers. They are non-combustible, non-inflammable, and non-explosive substances. They have a sweet, aromatic odor and have no offensive odor of sulphur or other impurities. They are uniform compounds and not mixtures. They have particularly great solvent power for sulphur at elevated temperatures.

They dissolve phosphorus, iodine, thirty volumes of chlorine, all hydrocarbons, waxes, resins (like kauri, copal, sandarac, damar and shellac), alcohols, fats and oils, fatty acids, dyes and purine derivatives. They have found great application in analytical work such as in the separation of dyes, fatty acids from hydroxy-fatty acids, phenols from polyhydroxy-phenols, caffeine from other purine derivatives, and so on.

Besides being useful for such a variety of purposes, they open up an extensive field in the synthesis of valuable products. Dichloro-ethylene can be used to synthesize thioindigo from thiosalicylic acid thus:

$$2C_6H_4 < \begin{matrix} SH \\ COOH \end{matrix} + C_2H_2Cl_2 = C_6H_4 < \begin{matrix} S \\ CO \end{matrix} > C =$$

$$C < \begin{matrix} S \\ CO \end{matrix} > C_6H_4 + 2HCl + 2\ H_2O.$$

Trichloro-ethylene can be used to synthesize ethyl-chloro-acetate ($CH_2ClCOOC_2H_5$), dichloro-acetic acid and phenylglycinester ($C_6H_5NHCH_2COOC_2H_5$), which forms the basis of the synthesis of indigo. It is important to note that acetylene is very much cheaper than acetate acid as a starting point in the synthesis of indigo. Tetrachloro-ethylene can be used to synthesize trichloro-acetic acid. Hexachlorethane can be used to make oxalic acid.

Chlor-compounds of the higher homologues of ethane will not be cheaply available on account of the scarcity of raw material and can only be made as by-products of coal-gas and oil-gas chlorination. When we reach as high as hexane, their chlorine compounds are either solids or liquids of very high boiling points and consequently will not be very useful as solvents. The unsaturated chloro-compounds of higher hydrocarbons, however, may find some application, as they have a lower boiling point than the corresponding saturated chloro-compounds. It is safe to say that chloro-compounds as solvents will never find an extensive application when made from hydrocarbons higher than pentane.

Compounds like chlorinated stearic acid are used as solvents in the manufacture of phonographic records and also in paint to prevent metallic corrosion. Chlorinated eucalyptol is used as a solvent for dichloramine-T. Other chlorine compounds like chloro-ethers, chloro-aldehydes, chloro-alcohols, etc., have not found any application as solvents.

d. Synthetic intermediates: There are many organic chlorine compounds, which though incapable of being used as such in arts and industries, are nevertheless very useful as intermediate products in the manufacture of other commercial products. Most chloro-hydrocarbons can be used to make unsaturated hydrocarbons of value. Organo-metallic compounds like zinc methyl ($Zn(CH_3)_2$, and magnesium-methyl-chloride are useful for preparing synthetic hydrocarbons, secondary and tertiary alcohols and fatty acids.

Trichloropropane or trichlorohydrin ($CH_2ClCHCl$ CH_2Cl B.P. 158°) though in itself not very useful, forms the basis of the synthesis of glycerol, a product of immense value in arts. Amylchloride and dichloropentane are useful in the synthesis of amylalcohol, amylacetate and isoprene $\begin{matrix} H_2C \\ H_2C \end{matrix} \diagdown\diagup C - C \diagup\diagdown \begin{matrix} CH_2 \\ H \end{matrix}$. Both amylalcohol and amylacetate are used extensively in the celluloid industry, while isoprene forms the parent substance of rubber, a substance which has entered into many phases of human needs.

Chloro-acetons can be used for the synthesis of citric acid or of glycerol. Monochloralkyls or chlorohydrocarbons can be used to build up higher hydrocarbons or for the introduction of alkyl groups in other organic compounds. Various acid chlorides like acetyl chloride or benzoyl chloride are used to make acid anhydrides or for the introduction of acetyl or benzoyl radicals.

The chlorine compounds are so vital in organic chemistry that but for their help directly or indirectly very few organic compounds could be prepared. Neither the amino group NH_2 nor the sulphonic group HSO_3, neither the sulphite radical SO_3 nor the hydroxyl acid radical OH, neither the nitro group NO_2 nor the nitrite radical NO_2, neither the acetyl radical CH_3CO nor the carboxyl group COOH, neither the alkyl nor the alkoxy group, can be substituted without their help. In fact, if any process is more useful, far-reaching and universal in application in organic chemistry it is chlorination. The halogens are the most intimate friends of the hydrocarbons and without their consent and coöperation no work of any kind is undertaken by hydrocarbons themselves.

If I may here be permitted to mention a personal experience in teaching, I would like to relate my experience in explaining the behavior of various hydrocarbons in organic chemistry.

To remove the confusion regarding the behavior of saturated and unsaturated hydrocarbons, I compared the saturated hydrocarbons to wealthy and completely self-satisfied people, while I called the unsaturated hydrocarbons needy beggars. Now beggars accept gifts but do not give anything in return. Saturated hydrocarbons on the other hand being "rich" are always ready, if they need anything, to give something in return. But the trouble is that they already have everything and need nothing. Hence they are the hardest to be induced to do anything. The only way to make them act as you desire is to approach them, not directly, but through their most intimate friends, the halogens, just as you have to have a "pull" to get a politician to do you a favor. If you can reach them through a friend they will do anything for you.

Among the indirect uses of chlorine can be mentioned its value as an oxidizing agent. Thus it can be used to make potassiumpermanganate from potassium manganate, $2K_2MnO_4 + Cl_2 = 2KMnO_4 + 2KCl$. It can be used in the manufacture of potassium ferricyanide from potassium ferro-cyanide. $2K_4Fe(CN)_6 + Cl_2 = 2K_3Fe(CN)_6 + 2KCl$. A similar application can be found in making lead peroxide from litharge or lead acetate (sugar of lead); $PbO + MgO + Cl_2 = PbO_2 + MgCl_2$ or $Pb(OOCCH_3)_2 + 2HOCl = PbO_2 + 2CH_3COOH + Cl_2$. Similarly superphosphate can be made from phosphate. $Ca_3(PO_4)_2 + 2\ SO_2Cl_2 + 4\ H_2O = 2CaSO_4 + Ca(H_2PO_4)_2 + 4HCl$. It can be used in making artificial camphor from Isoborneol, which in turn can be made from turpentine or pinene.

Isoborneol Camphor

$$C_{10}H_{17}OH + Cl_2 = C_{10}H_{16}O + 2HCl$$

By its use pure cellulose can be obtained from woodpulp.

Dr. Wintlein mentions an experiment whereby 100 parts, by weight, of dried pine-wood, treated by lime and chlorine, gave 50 parts, by weight, of pure cellulose. Bleaching powder can be used to produce pure oxygen gas from what is technically known as lavosite.

Thus it can be seen that chlorine has an extensively wide application in both inorganic and organic industries and supplies many human wants. It bleaches our linen, purifies our water, protects us from epidemic diseases and helps us in making dentistry and surgery painless. It is our companion in homes, companion in camp, companion in peace and companion in war.

The end of this war will find an enormous excess of chlorine in this country and the problem of turning this vast otherwise nuisant material into useful channels will be before us. The electrolytic alkali manufacturers of this country will do well to think and not wait until they are face to face with it. We must remember that a stitch in time saves nine. A little foresight and forethought will go a long way in helping to solve this problem.

Some manufacturers think that if they seek today new applications for their by-products they would be trespassing on the field of their present customers who are buying chlorine. But it should be remembered that a customer buys chlorine only when he can make money for himself. He makes only such chlorine products as are in demand at a good price. He is not interested in buying chlorine to find new uses for it. Consequently he is not the man to experiment. As a matter of fact it is the manufacturer who lives or dies and who is the one most concerned. It is up to him to sound the depth of this unexplored region.

Research Department,
Niagara Alkali Co.,
Niagara Falls, N. Y.

Basic Exchange in Permutite

Rothmund and Kornfeld in *Zeitschrift anorg. Chemie* 103, pp. 129-163, state that the basic exchange which takes place between hydrated aluminosilicates, such as the soil zeolites or the artificial product permutite, and neutral salt solutions is a true chemical substitution of an alkali metal for an earth and not a process of adsorption. In the case of permutite, equilibrium is rapidly established between the solid and a neutral salt solution, and the composition of the resulting permutite is found to depend upon the relative concentrations of the interchangeable bases in solution.

The Development of the Ferro-Manganese Industry in the United States Since 1914*

By Theodore Swann

PRIOR to 1914 the United States produced less than one-half of its ferro-manganese requirements, and in 1914 only 54% out of a total 183,728 tons of ferro-manganese produced and imported. In 1917 the total production and imports increased to 331,381 tons, of which 286,000 tons, or 86%, was produced in the United States, and in 1918 the percentage of home production will not be less than 90%.

Sources of Manganese Supplies

It is well known that under pre-war conditions the world's supply of manganese ore came mainly from Brazil, India and Russia. Thus the shortage of shipping brought about by the war made it necessary that the United States develop to the greatest extent possible its own manganese ore resources.

The production of manganese ore in the United States in 1914 was 2635 tons; this was insufficient to make one-half of one per cent of the ferro-manganese required.

In 1915, domestic production of manganese ore increased to 9709 tons, or enough to make about two per cent of our requirements. During 1916 the domestic production increased more than treble that of the previous year, we producing 26,997 tons of manganese ore, or enough to make less than three per cent of our increased ferro-manganese requirements. In 1917 the production of high-grade domestic ore quadrupled that of the previous year's output. We produced 113,734 tons of high-grade manganese ore, or enough to make over 10% of the ferro-manganese required.

The domestic ore production of 1917 only supplemented the foreign ores, the shipment of which was rapidly becoming more difficult. During the first six months of the present year 1918, we find the high-grade domestic manganese ore production greater than that of the entire year of 1917, with prospects for decided increase in the second half over that of the first half.

Production of Ferro-Manganese

During July, 1918, a total of 30,370 tons of ferro-manganese was produced containing 20,226 tons of metalic manganese; 23,021 tons of spiegeleisen was produced containing 4698 tons of metallic manganese, making a total of 24,924 tons of metallic manganese in the total ferro-manganese and spiegeleisen produced. The percentage of metallic manganese derived from domestic ores in the above tonnage for July 1918 was 47.9 per cent.

It has been estimated from the consumption to date this year that the iron and steel industry will require during the remainder of this year and the first half of 1919, 31,000 tons per month of metallic manganese in the form of ferro-manganese and assuming that the average grade will be 65%, the monthly requirements of ferro-manganese will be 32,300 tons; in addition 3000 tons per month of metallic manganese in the form of spiegeleisen will be required; assuming the average grade to be 18% the monthly requirements will be 16,500 tons.

The total metallic manganese requirements for the year ending June, 1919, for both ferro-manganese and spiegeleisen are therefore assumed to be 288,000 tons; from the best information available at this time the United States will produce ores that will contain at least 50% of the manganese content required to make this tonnage of ferro-manganese and spiegeleisen.

At the May meeting of the American Iron and Steel Institute, Mr. C. R. Ellicott presented a most complete and instructive paper, entitled, "The Conservation of Manganese." In addition to the facts so ably presented by Mr. Elicott, we desire to pay tribute to the many producers of domestic manganese ore who by their efforts are rapidly making the United States less dependent upon other countries for our supply of manganese ores. We strongly urge that it is the patriotic duty of both the producers and users of manganese alloys to encourage in all ways possible the production of domestic ores and to further break away from the old prejudice against the use of lower grade alloys.

Advantages of Silico-Manganese Alloys

It has been suggested that the steel industry could further aid in the conservation of shipping by using, when possible (in many instances to their direct advantage), silico-manganese which could be made from high silica domestic ores. Some of our prominent metallurgists consider the advantages of silicon alloyed with manganese to be:

First: The silicon forces down the carbon, giving the desired low carbon alloy for the steel addition.

Second: As a dioxidizer the combined selective action of silicon and manganese will be more active as a dioxidizer than either element alone.

Third: The resultant combined oxides forming manganese silicate will, due to its greater fluidity, be eliminated from the metal more readily than the oxides of either alone.

There are numerous deposits of manganese ore too high in silica to be used in making ferro-manganese. These however, are available for making silico-manganese.

Manganese Slags

It is possible to make silico-manganese from high slags carrying from 10% and up of manganese and also from manganese ores carrying as low as 18% manganese and as high as 40% silica. While it is not so attractive commercially to use slags and very long manganese ores, this source of supply has been proven to be available by one electric furnace producer. This producer made from slags, running 10 to 17% manganese, several carloads of silico-manganese analyzing about 64% manganese, 12% iron, 23% silicon, and 0.60% carbon. It may be of interest to note that the average slags produced with the above metal run under 4% in manganese.

The manufacture of ferro-manganese in the electric furnace is one of the important developments in connection with the utilization of domestic manganese ores, especially where the plants are located near the ore mines. Not only are such plants conserving ocean transportation, but railway transportation as well.

[*Abstract of paper presented at the Fourth National Exposition of Chemical Industries, Sept. 27, 1918.]

Perhaps the greatest value today of the electric furnace producing ferro-manganese, is the conservation of coke. The majority of electric furnaces are operated and heated by hydro-electric power instead of coke as in the blast furnace.

In July, 1918, over 7½% of the entire production of ferro-manganese was made in the electric furnaces. It is estimated that by the end of this year electric furnaces will be producing about 15% of the total ferro-manganese produced in the United States.

The slag and volatilization losses in the smelting of the ferro-manganese is an ample field for the conservation of our manganese supply. The fundamental causes underlying such losses are problems to be further worked out by our metallurgists. It is believed that it is possible so to improve the past general average practice as to increase the recovery by 10%. If such increase could be made, it would save about 30,000 tons of metallic manganese and thus release over 75,000 tons of shipping.

Increased Production of Artificial Abrasives

A MARKED increase in the output of artificial abrasives in the first half of 1918, as compared with the first half of 1917, is shown by figures compiled by Frank J. Katz, of the United States Geological Survey, Department of the Interior, and obtained in coöperation with the Mines Branch of the Canada Department of Mines. There was little change in the output of corundum and a decrease in the output of emery.

Emery and Corundum

During the first half of 1918 emery ore was produced by seven operators in the Peekskill district, in New York, and by one in southern Virginia. Corundum is produced from one mine in Macon County, N. C., and by one company operating in Renfrew County, Ontario. The combined mine output of emery and corundum in the United States and Canada from January 1 to June 30, 1918, was 5455 short tons. During the same period the producers sold, shipped, or used in the manufacture of abrasive articles approximately 4500 short tons, and the stock on hand at the mines June 30 was about 1500 short tons. As compared with the same period in 1917, there was a large decrease in the quantity of emery mined, and the output from January to June, 1918, inclusive, was considerably less than half of the mine output of emery for the entire year 1917. During the first half of 1918 corundum was produced at about the same rate as in 1917.

Artificial Abrasives

Artificial carbide abrasives, including carborundum, crystolon and carbolon, were produced during the first half of the year 1918 by two companies in the United States, operating plants at Niagara Falls, N. Y., and at Blasdell, N. Y., and by three in Canada, operating plants at Shawinigan Falls, Quebec, and at Chippewa and Thorold, Ontario. The plant output of crude carbide abrasives was 6583 short tons. During the same period the producers sold or used in the manufacture of abrasive materials 5633 tons, and on June 30 there remained in their hands as stocks 2840 tons.

Aluminium oxide abrasives, including alundum, aloxite, exelon, lionite and natite, were manufactured in the United States by four companies, three of which operated plants at Niagara Falls, N. Y., and one at Blasdell, N. Y., and in Canada by five companies, which operated plants at Niagara Falls, Chippewa and Thorold, and two at Hamilton, Ontario. The combined output of these plants in the first half of 1918 was 28,341 short tons. During the same period the producers sold or used in the manufacture of abrasive materials 28,161 short tons, and on June 30 there remained in their hands 26,221 short tons. The combined figures for carbide and alumina abrasives for the first half of 1918 are: Manufactured, 34,974 short tons; material sold or used, 33,794 short tons; and stock in hands of producers June 30, 29,061 short tons. As compared with the first half of 1917, there was an increase in production of nearly 60 per cent. The production in the first half of 1918 was approximately equal to 62 per cent of that for the whole year 1917.

Consumption of Chlorine Bleach Curtailed

SPECIFIC reductions in the use of chlorine bleach in any form in the pulp and paper industry have been agreed upon by the Pulp and Paper Division of the War Industries Board and will shortly become legally effective as follows:

Sulphite Pulp

The use of chlorine by any individual user in the bleaching of sulphite pulp is restricted to an amount not greater than 40 per cent of the of the amount now being used; that is to say, the amount of chlorine contained in 35 per cent commercial bleaching powder now used per 100 pounds of sulphite pulp will be computed and the user will be allowed 40 per cent of this amount in each 100 pounds of sulphite pulp hereafter bleached. Variation in the use of bleach per 100 pounds of sulphite pulp is permitted for the purpose of maintaining uniform color, provided the average used per 100 pounds of the pulp bleached does not exceed the permitted use of bleach per 100 pounds.

Soda Pulp

The use of chlorine by any individual user in the bleaching of soda pulp is restricted to an amount not greater than 70 per cent of the amount now being used; that is to say, the amount of chlorine contained in 35 per cent commercial bleaching powder now used per 100 pounds of soda pulp will be computed and the user will be allowed 70 per cent of this amount in each 100 pounds of soda pulp hereafter bleached. Variation in the use of bleach per 100 pounds of soda pulp is permitted for the purpose of maintaining uniform color, provided the average used per 100 pounds of the pulp bleached does not exceed the permitted use of bleach per 100 pounds.

Sulphate Pulp

The use of chlorine in the bleaching of sulphate pulp is specifically forbidden.

Old Papers, All Kinds

The use of chlorine in the bleaching of recovered old papers is restricted to 0.35 per cent of stock.

Chemical Control of Water Softeners

A Discussion of the Reactions Involved in the Lime-Soda-Ash Process and the Derivation of a Practical and Simple Field Routine Analysis

By LOUIS F. CLARK

THE process of softening water by the use of the reagents, calcium hydrate or oxide, lime, together with sodium carbonate, soda ash, is a venerable one. The fundamental chemistry of the process and the machinery by which it is applied, may be found described in textbooks on analytical chemistry. Local conditions, however, often demand a special and convenient method of control for the process. The method as herein set forth has been evolved by reason of the following conditions:

1.—The water to be treated is subject to seasonal variation.
2.—The water is treated at widely distributed stations, so that the various machines require individual regulation.
3.—The lime used in the machines has a variable CaO content depending on the degree of calcination.
4.—The soda ash ranges from 45 to 90 per cent Na_2CO_3, according to the time it has effloresced in dry air.
5.—The operation of the individual softening machines must be controlled by an operator who can make field tests to determine the proportions of materials required.
6.—The equipment for conducting the tests must be simple and portable.
7.—The operator usually will have available only the water to be softened, as he will carry no distilled water.

An average analysis of the hard water to be softened will show that it is of such composition that any substitution process, whereby the scale-forming alkaline earth salts are precipitated and those of sodium substituted, will leave such an enormous amount of material in solution after treatment that evaporation residues will require frequent removal. Thus it is urgent that the individual softening machines receive careful regulation to avoid possible excesses when precipitants of such variable composition are in use.

AN AVERAGE WATER ANALYSIS

	Million	Grains, U. S. Gal.
Silica	28.0	1.63
Sodium Chloride	156.2	9.11
Magnesium Chloride	19.2	1.12
Magnesium Sulphate	348.4	20.32
Calcium Sulphate	618.0	36.04
Calcium Bicarbonate	202.0	11.78
	1371.8	80.00

Hardness tests on water by the use of soap solutions do not determine the exact quantities of reagents necessary for softening. A field analysis may be made by titration of the water with a suitable HCl solution, together with proper additions of the various reagents actually used in the softening process. It is of first importance that the HCl solution used should be of such strength that in any titration the operator can read directly from the burette in pounds per 1000 gallons, or a simple multiple thereof, because the machines require the weight of the precipitants in pounds for each 1000 gallons of water to be treated.

The most satisfactory report of a water analysis is given when the components are expressed as parts per million. If we accept the specific gravity of the water as unity, we may accept milligrams per liter as equal to parts per million. By the relation of weights we can arrive at the factor,[1] 0.0583, by which parts per million should be multiplied to give grains per U. S. gallon; further if we consider gms. of materials in solution in 100 cc., we may multiply such weight by 83.3 and get pounds per 1000 gallons.

Other points it is necessary to consider here are that, as will be subsequently shown, it is convenient to consider the lime as having a certain percentage of CaO content rather than $Ca(OH)_2$ even though the material has been slaked, by reason of the fact that the molecular weight of CaO (56) is nearly equal to one-half the molecular weight of Na_2CO_3 (106), at least sufficiently near, that our HCl solution can be adjusted so that its factor for lime will be one-half its factor for soda ash. Finally, the calcium in solution in this water in excess of that satisfied by the mineral acids is regarded as being in solution as bicarbonate, not carbonate. Basicity determination on the water on this assumption checks the value of calcium so existing, calculated from a complete analysis.

With these points in view we can proceed to calculate the strength of hydrochloric acid solution required.

Assume K = gms. $Ca(HCO_3)_2$ in 100 cc. raw water.

Let x = gms. CaO required to ppt. K as $CaCO_3$.

As x : K :: 56 : 162,

x = 0.345 K.

Let Y = gms. HCl equivalent to K in titration.

Y : K :: 72.9 : 162.

Y = 0.45 K.

By derivation as given in a previous paragraph

x(83.3) = X, lb. lime per 1000 gal.

$\therefore X = (83.3)\ (0.345)\ K = 28.75\ K$ lb. CaO required per 1000 U. S. gallons, but with a 100-cc. sample of water, Y = 0.45 K.

And Y must = 28.75 K cc. so that burette will read lb. per 1000 gallons,

Hence Y = 0.45 K gms. HCl existing in 28.75 K cc. of acid, or 1 cc. = 0.01565 gm. HCl.

This acid solution has been found too strong for use and one-fourth this strength has been arbitrarily adopted. If we make an HCl solution so that 1 cc. $= \frac{0.01565}{4} = 0.00391$ gm. HCl, then the equivalent of 1 cc. in CaO equals (0.00391) (56) ÷ 72.9 = 0.0030 gm. and the equivalent in soda ash of 1 cc. equals

[1] 8.33 (lb. in U. S. gal.) × 7000 (gr. in lb.) ÷ 1,000,000 = 0.0583.

(0.00391) (106.1) ÷ 72.9 = 0.0057 gm. Na_2CO_3, but if the molecular weight of Na_2CO_3 were exactly equal to twice the molecular weight of CaO, then we should have found that 1 cc. of the HCl = 2(0.0030) = 0.0060 gm. Na_2CO_3 instead of 0.0057 gm. Na_2CO_3.

If 1 cc. of the HCl = 0.0060 gm. Na_2CO_3 then 1 cc. of HCl = 0.00413 gm. HCl instead of 0.00391 gm. Let us take an average, (0.00413 + 0.00391)2 = 0.00402 gm. HCl required to the cc.

Such a solution can be made by using 1 cc. of concentrated acid per 100 cc. of distilled water and adjusted by titration against standard Na_2CO_3 solution.

We arrived at the calculated strength of this acid solution by assuming titration on a 100-cc. sample. With such a sample, therefore, 1 cc. of this acid is equivalent to $\frac{1}{4}$ lb. of CaO or $\frac{1}{2}$ lb. of Na_2CO_3. These are the simple multiples referred to above.

This solution of HCl is prepared at the central laboratory and carried with the field apparatus. In order to make the field tests, the operator is preferably equipped as follows:

1. One 2½-liter bottle of standard HCl solution.
2. One 50-cc. burette.
3. One balance to weigh out 10-gm. samples.
4. One 100-cc. graduate.
5. Two funnels. Filter paper.
6. Two 200-cc. Erlenmeyer flasks.
7. One glass tube 20 in. long and suitable single hole stopper to fit the Erlenmeyer.
8. Two 200-cc. beakers.
9. One oil burner to heat solutions.
10. One pound of ammonium chloride.
11. Solutions of methyl orange and phenolpthalein indicators.
12. One small mortar and pestle.

The above equipment comprises the portable laboratory which the operator can carry from station to station for making tests on the individual machines. In making these tests there are two general possibilities in connection with the use of CaO and Na_2CO_3 with the water to be softened. Theoretically the CaO should only be used to precipitate the $Ca(HCO_3)_2$ as $CaCO_3$ leaving the calcium and magnesium sulphates to be precipitated as carbonates by the Na_2CO_3. However, in cold solution Na_2CO_3 does not completely precipitate magnesium as $MgCO_3$, because of the formation of soluble magnesium bicrabonate. This may be prevented by introducing excess lime to the point of completely precipitating all the magnesium as hydrate and to form a protective alkalinity so as to avoid the possibility of magnesium bicarbonate formation. When this condition is established, the magnesium is completely precipitated in the cold by the Na_2CO_3. Obviously such a procedure is more expensive, because the excess CaO so used must be thrown out by using its equivalent of Na_2CO_3, so that for each $Mg(OH)_2$ precipitated one calcium ion goes into solution as sulphate. However, the additional cost incurred by this excessive use of CaO is small compared to the benefit derived from the more complete removal of magnesium from the boiler water. On this basis therefore the following procedure is set down:

As $Ca(HCO_3)_2$ is alkaline to methyl orange until the following reaction is complete

$$Ca(HCO_3)_2 + 2HCl = CaCl_2 + 2CO_2 + 2H_2O,$$

Therefore—(a) Take 100 cc. raw water, add 2 drops of methyl orange. (b) Titrate cold = A_1 cc. of standardized HCl.

We may divide A_1 cc. by 4 and find the pounds of chemically pure CaO required per 1000 gallons of raw water to precipitate all the $Ca(HCO_3)_2$ as $CaCO_3$. But for the present, we note down A_1 cc. and divide by 2 to obtain the pounds per 1000 gallons of CaO required, which will be explained later.

Since 1 cc. of HCl solution equals (0.00402 ÷ 72.9) 56 = 0.00309 gm. CaO, if it were possible, we might put 0.1545 gm. of chemically pure CaO into 100 cc. of distilled water and titrate the mixture with exactly 50 cc. of HCl solution. Further, we could multiply the amount used by 2 and read 100 per cent as the purity of CaO. Similarly we can put 0.1545 gm. of any lime into 100 cc. of distilled water, titrate and multiply the cc. used by 2 and get the per cent of CaO in the lime. Putting 0.1545 gm. into 100 cc. is the same as putting 10 gm. into 6470 cc., a procedure practicable in the field. However, as there is no distilled water to be had outside of the laboratory the 100 cc. of the raw water will react with the equivalent of A_1 cc. expressed as c.p. CaO. For each 100 cc. of the 6470 cc., therefore, this amount of c.p. CaO is precipitated as $CaCO_3$. Further we know that when we put this amount of lime into such water, some very insoluble $Mg(OH)_2$ is precipitated. Thus the simple addition of lime to the water, boiling, cooling and titrating with phenolphthalein does not usually give a sufficiently sharp end-point. For this reason, let us take about 150 cc. of this mixture, boil, cool and add NH_4Cl. Then any $Mg(OH)_2$ will go into solution as $MgCl_2$ and yield an equivalent amount of NH_4OH. We can now filter this solution free from $CaCO_3$ on the assumption that the boiling has rendered the $CaCO_3$ crystalline and scarcely at all soluble in the NH_4Cl solution. Take 100 cc. of the filtrate, add 2 drops of methyl orange and titrate to get A_2 cc.

Put 10 gms. of lime into 6470 cc. of water and mix well.

Take about 150 cc. of well-agitated mixture into a flask (boil under condenser and cool).

Add NH_4Cl to the cold mixture in the flask.

Thoroughly agitate, settle for 15 minutes and filter cold.

Take 100 cc. of filtrate for titration which takes A_2 cc. of acid. Then: $2(A_1 + A_2)$ = per cent of CaO in the lime.

This summation $A_1 + A_2$ represents the number of cc. of acid that would have been used in the titration, were it possible to conduct the operation in distilled water. Note also that no distilled water was used in the manipulation.

If we had not added the NH_4Cl to the above mixture but had filtered the mixture at once, a titration of the filtrate would have revealed the CaO in solution, which had not been used either to precipitate $Ca(HCO_3)_2$ as $CaCO_3$ or $MgSO_4$ as $Mg(OH)_2$. Then since $A_1 + A_2$ represents the total CaO added, we subtract A_2, the excess of CaO added, and divide by 4 to find the pounds of chemically pure CaO required per 1000 gallons of water treated. This is of course based on the assumption that there is sufficient volume of water used to dissolve all the CaO existing in the 10 gms. of lime added and that no precipitation of CaO occurs from atmospheric CO_2 during the manipulation. These conditions do not always exist. Hence the value of total CaO required, found in this way, should merely be

regarded as a guide. Further it should be remembered that this is the extreme limit of the requirements for CaO. It is not necessary to use enough CaO to precipitate all the $MgSO_4$ as MgOH, it is only desirable to partially accomplish this, so as to have alkalinity enough to prevent the formation of magnesium bicarbonate. Therefore it is advisable to but slightly exceed the ½A value for CaO. This condition for raw water is usually reached when 2 ½A or ¼A lb. c.p. CaO per 1000 gallons are used. The value found at A_3 is merely noted for a check on lime consumption.

Take about 150 cc. of well-agitated lime mixture.

Filter without addition of NH_4Cl.

Titrate 100 cc. of filtrate = A_3 cc. HCl solution.

Then: $(A_1 + A_3 - A_2) \div 4$ equals pounds per 1000 gallons of c.p. CaO required, subject to the minor variations mentioned above.

One cc. of the HCl solution equals $(0.00402 \div 72.9)(106.1) = 0.00585$ gms. Na_2CO_3. If we put 0.2925 gms. c.p. Na_2CO_3 (anhydrous) into 100 cc. of distilled water and titrate it using methyl orange as an indicator with exactly 50 cc. of the HCl solution, we could multiply the cc. of acid so used by two and prove the material to be 100 per cent. Similarly, when we add 0.2925 gm. of any soda ash to 100 cc. of distilled water or 10 gms. to 3420 cc. and titrate 100 cc. of the solution, we find the percentage of Na_2CO_3 by multiplying the cc. used by two. Usually there is no distilled water in the field supplies but since 100 cc. of crude water is equivalent to A_1 cc. of acid solution because of its bicarbonate alkalinity; hence, if the titration of this solution requires A_4 cc. we can say $2(A_4 - A_1)$ the per cent of Na_2CO_3 in the soda ash. It should be noted that this solution of soda ash added to the raw water will cause a precipitation of all the calcium existing as $CaSO_4$, etc., and of at least part of the magnesium. The $Ca(HCO_3)_2$ is not affected. If we agitate the mixture well and take a 100-cc. sample to which a pinch of NH_4Cl has been added to dissolve the $MgCO_3$ the $CaCO_3$ precipitate is crystalline and alkaline to methyl orange. It is advisable to add the acid slowly near the end point so as not to exceed the $CaCO_3$ equivalent.

Put 10 gms. of soda ash into 3420 cc. of water.

Agitate well and take 100 cc. of the mixture.

Add NH_4Cl to 100 cc. of mixture.

Add 2 drops of indicator and titrate, which takes A_4 cc. of the acid solution.

Then: $2(A_4 - A_1)$ equals the per cent of Na_2CO_3 in the soda ash.

If 100 cc. of raw hard water were treated with a given weight of c.p. anhydrous Na_2CO_3 and the solution evaporated to dryness, taken up in distilled water, filtered and titrated, we could determine the Na_2CO_3 consumed in precipitating the calcium and magnesium sulphates, etc. The $Ca(HCO_3)_2$ is decomposed and precipitated as $CaCO_3$ by the evaporation. Such a process can not be conveniently carried out in the field. However, when the CaO is added to the 6470-cc. portion of the water, it precipitates $Ca(HCO_3)_2$ as $CaCO_3$ and $MgSO_4$ as $Mg(OH)_2$. For each equivalent of magnesium so precipitated, one of calcium goes into solution as sulphate. Therefore, when Na_2CO_3 is subsequently added to this mixture, the same amount of Na_2CO_3 is consumed to precipitate the newly formed $CaSO_4$ as would have been required to precipitate the original $MgSO_4$. As far as the total alkalinity of the filtrate is concerned, it is not important whether the MgO is changed to $MgCO_3$ or not. If the carbonate precipitation is conducted in a solution containing any free alkali, then bicarbonate does not form, and the magnesium is completely precipitated in the cold. Also if to any solution containing CaO an excess of Na_2CO_3 is added and the solution filtered, the total alkalinity of the filtrate is equal only to the alkalinity of the Na_2CO_3 introduced, and the original alkalinity due to CaO remains on the filter paper as $CaCO_3$. On this basis then we can take 3420 cc. of the lime mixture already prepared, add 10 gms. of the same soda ash used at A_4, agitate well, settle, filter, and titrate 100 cc. to get A_5 cc. Under these conditions the magnesium is completely precipitated as carbonate in the cold, due to the presence of the NaOH or CaO which prevents the formation of magnesium bicarbonate. $\frac{1}{2}(A_4 - A_1 - A_2)$ = lb. of c.p. Na_2CO_3 per 1000 gallons required for reacting with Ca and Mg sulphates.

Agitate lime mixture made at A_2.

Measure off 3420 cc. of this lime mixture and add 10 gms. soda.

Agitate well and settle.

Filter and titrate 100-cc. portions which equals A_6 cc.

At this point we might mention that some prefer to describe water in terms of degrees of temporary and permanent hardness. As a basis for discussion we might define for ourselves one degree of hardness as 1 mg. per liter of $CaCO_3$. The degrees of temporary hardness are those dispelled by boiling or the parts per million of $Ca(HCO_3)_2$, expressed as $CaCO_3$. Then since we can theoretically express any salt by its chemical equivalent, weight of CaCO, by manipulation of the relative molecular weights, we can say: $\frac{120 \times 100}{4 \times 56} A_1 = 53.5\, A_1$ = degrees of temporary hardness, where 120 is the reciprocal of 0.00835, the number of which mg. per liter must be multiplied to give pounds per 1000 gallons, and 56 is the molecular weight of CaO and 100 of $CaCO_3$. Moreover, since the amount $(A_4 - A_1 - A_2) \div 2$ found at A_5 may be considered as the Na_2CO_3 required to precipitate the Ca and Mg mineral acid salts and since we regard the molecular weight of Na_2CO_3 as twice that of CaO we may write $\frac{100 \times 120}{4 \times 56}(A_4 - A_1 - A_2) = 53.5\,(A_4 - A_1 - A_2) =$ the calcium and magnesium mineral acid salts expressed as $CaCO_3$ = degrees of permanent hardness. It may be urged that these degrees of hardness be determined by the use of a standard soap solution and calculation of softening reagents required made therefrom. Such determinations have not been found reliable nor anywhere near as extensive in the information conveyed as is required in this work.

As a further demonstration upon the action of the softening machines, we see from the following equations that reagents can be weighed in grams and put into 8.35 liters of water. The same conditions will obtain then as in the case of using pounds per 1000 gallons. Thus the operation can be observed on a small scale.

1 lb. per 1000 gal. = 453.6 gm. per 3785.4 liters = 1 gm. per 8.35 liters.

Another set of tests may be made upon the machines in operation. Consider the liquid which issues from the lime tank. This is milk of lime emulsion and contains CaO in solution. Also CaO, $CaCO_3$ and $Mg(OH)_2$ are in suspension. It must be a milk of lime, not merely a solution, in order to convey in a small volume a sufficient amount of CaO for the entire volume of water under treatment. Such an amount is in excess of the solubility of CaO in the small volume of water passing through the lime tank. Hence what we want to know in such an emulsion is its actual content per 1000 gallons of MgO and CaO in solution and suspension. Here again we can use NH_4Cl under conditions as previously described. Thus we take about 150 cc. of this mixture, boil to render $CaCO_3$ crystalline, cool, add NH_4Cl, agitate and settle. This will dissolve $Mg(OH)_2$ and permit any CaO in suspension to go into solution. We can filter such a mixture, leave the $CaCO_3$ on the paper and titrate 100 cc. of the filtrate which equals B_1 cc. We know that B_1 cc. includes $Mg(OH)_2$ precipitated by CaO but this makes no difference for it represents alkali nevertheless.

Take a 150-cc. sample of the emulsion issuing from lime tank. Boil, cool, add NH_4Cl, agitate and filter.

Titrate 100 cc. of filtrate to get B_1 cc.

$B_1 \div 4 =$ pounds c.p. CaO issuing in each 1000 gallons that flows out of this tank.

It may be advisable to know the condition of the water as it completes its journey through the softening machines. A sample may be taken above the filters. The procedure is nearly the same as at A_2. Treat a 3420-cc. sample with a small amount of lime (2 gms.) to render alkaline and proceed as if it had no previous addition of Na_2CO_3. Carry through the determination exactly as if it were the A_2 lime mixture. Filter the liquid after boiling under the reflux condenser as before and titrate 100 cc. which will give B_2 cc. We know that at the time these tests are made the procedure of putting 10 gms. of soda into 3420 cc. of water introduces an equivalent of $(A_4 - A_1)$ in terms of c.p. Na_2CO_3. If we titrate the liquid from this test and find it to be B_3 cc. we can write: $\frac{1}{2}(B_3 - A_4 + A_1) =$ $\pm$lb. per 1000 gallons of c.p. Na_2CO_3. The plus or minus sign in the result is important because: If B_3 is greater than $(A_4 - A_1)$ then the sign is plus and we know that there was free sodium carbonate in the solution at the time that test was made, and exactly as much as is expressed by the solution of the equation.

If B_3 is less than $(A_4 - A_1)$ then the sign is minus and we know that there was an insufficient amount of Na_2CO_3 present to complete the precipitation of the alkaline earth salts by the exact amount shown by the solution of the equation.

Take 3420 cc. of water above filters, and add about 2 gm. of lime.

Add 10 gms. of soda ash on which $(A_4 - A_1)$ has just been determined.

Agitate well and settle as with A_2.

Filter and titrate 100 cc. to get B_3.

Then, $(B_3 - A_4 + A_1) \div 2 = \pm$lb. per 1000 gallons c.p. Na_2CO_3.

If positive, lb. per 1000 gallons excess present.

If negative, lb. per 1000 gallons short.

This is an identical procedure as for B_3 and is made upon the water storage tanks. It may often be possible to make slight corrections by additional reagents even after the water has entered the storage tank. Though these methods may seem complicated and perhaps are somewhat theoretical, the practical directions as issued to the operator are simple and may be summarized as follows:

Directions to operator

A_1 Take 100 cc. raw water, add 2 drops of indicator. Titrate cold with HCl solution $= A_1$ cc. ($\frac{1}{2}A_1$ = lb. per 1000 gal. c.p. CaO required. This figure divided by the per cent of CaO gives lb. per 1000 gallons crude lime required).

A_2 Put 10 gms. crude lime into 6470 cc. of water and agitate.
Take about 150 cc. of well-agitated mixture into a flask, boil and cool.
Add a small amount (2 grains) of NH_4Cl to the cold mixture in the flask.
Stir mixture in flask well and filter cold.
Titrate 100 cc. of filtrate in the cold with HCl solution $= A_2$ cc.

Then: $\frac{1}{2}(A_1 + A_2)$ per cent CaO in the crude lime.

A_3 Take about 150 cc. of the above well-agitated lime mixture.
Filter without addition of NH_4Cl.
Titrate 100 cc. of filtrate with HCl $= A_3$ cc.

Then: $(A_1 + A_2 - A_3) \div 4 =$ lb. per 1000 gal. c.p. CaO required by the water. (This figure divided by the per cent of CaO gives lb. per 1000 gallons of crude lime required, when the absolute limit of lime consumption is wanted.)

A_4 Put 10 gms. soda ash into 3420 cc. of water.
Agitate well and take 100 cc. of mixture.
Add a pinch of NH_4Cl to the 100-cc. mixture.
Titrate in the cold with HCl solution $= A_4$ cc.

Then: $2(A_4 - A_1) =$ per cent of Na_2CO_3 in the soda ash.

A_5 Agitate lime mixture made at A_2.
Measure off 3420 cc. of this lime mixture and add 10 gms. soda ash.
Agitate well and settle.
Filter and titrate 100-cc. portions with HCl solution $= A_5$ cc.

Then: $(A_4 - A_1 - A_5) \div 2 =$ lb. per 1000 gallons c.p. Na_2CO_3 required by the raw water. This figure divided by the per cent of $NaCO_3$ found at A_4 gives the lb. per 1000 gallons of crude soda ash required.

Solutions from lime tank

(a) Take 150 cc. of sample of emulsion issuing from lime tank.
(b) Boil, cool, add NH_4Cl and filter.
(c) Titrate 100 cc. of filtrate with HCl solution $= B_1$.

Then: $\frac{1}{4}B_1 =$ lb. c.p. CaO isuing in each 1000 gallons out of this tank.

Sample taken above the filters

(a) Take 3420 cc. of water, add 10 gms. soda ash and about 2 gms. of lime. (This must be same soda ash used at A_4 etc.)
(b) Agitate well and settle mixture as for A_2.
(c) Filter and titrate 100 cc. of filtrate cold $= B_3$.

Then: $(B_3 - A_4 + A_1) \div 2 = \pm$lb. per 1000 gal. c.p. Na_2CO_3. $+ =$ excess, $- =$ deficiency.

Potrerillos, Chile.

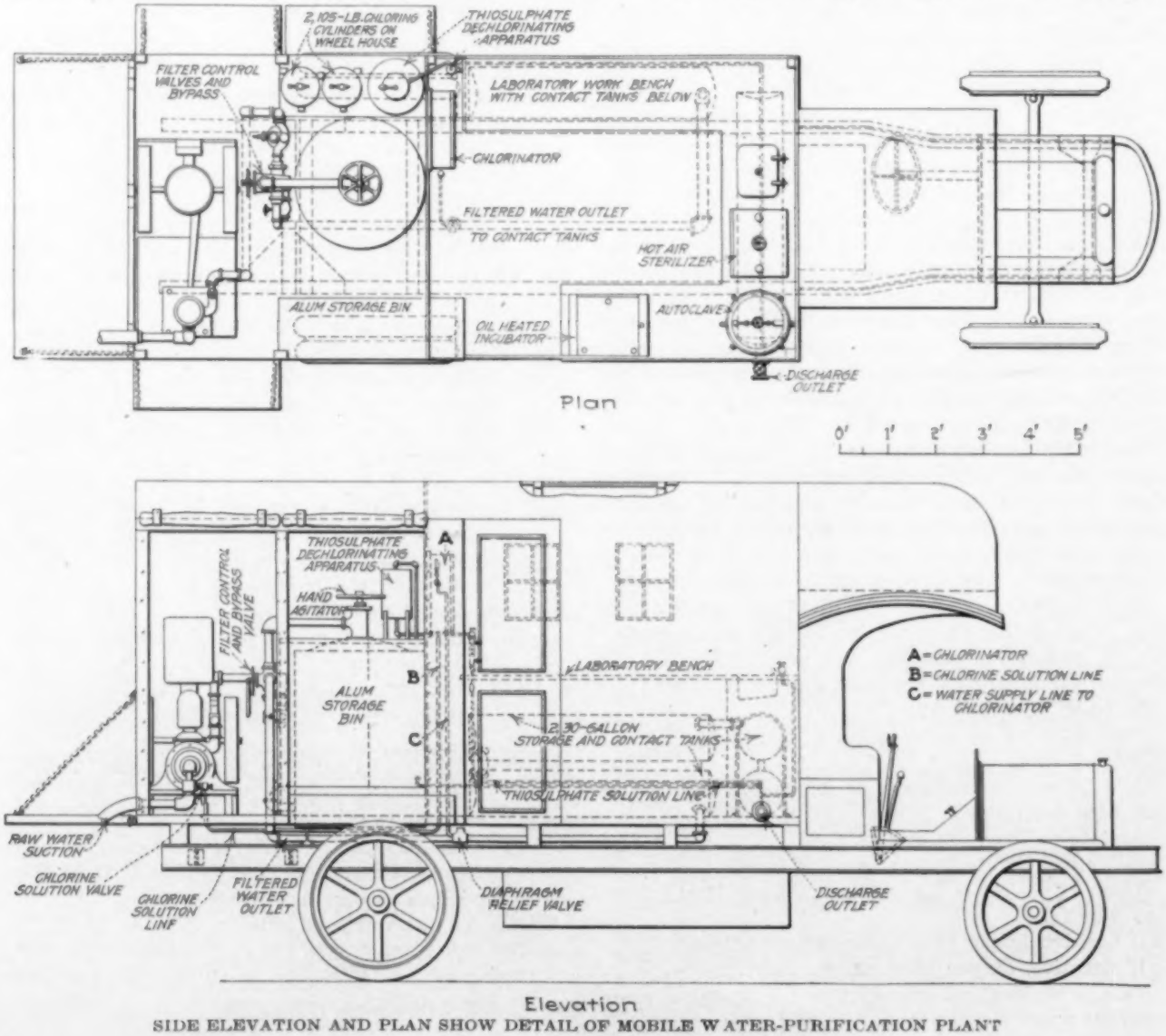
Mobile Chlorine Water-Purification Plant

Trucks Equipped with Mechanical Filter, Chlorinating Apparatus and Testing Laboratory Sterilize Water for Troops

By Robert K. Tomlin, Jr.
War Correspondent of Chemical & Metallurgical Engineering

FOR emergency filtration, sterilization and analysis of water supplied to American troops at the front in France, specially designed mobile plants, mounted on standard motor trucks, have been placed in service. The first outfits of this sort were sent to a division in an American sector early in June. They are the forerunners of others which, it is planned, will be used pretty generally by the American Expeditionary Forces for producing temporary supplies of potable water pending the creation of the more or less permanent "water points" which present military engineering practice has developed for the advance zones. While they embody no principles of water treatment which have not been employed for years past in the United States, the portable plants are nevertheless unique in so far as sanitary engineering practice of the allied armies is concerned. They represent an ingenious adaptation of standard American methods of water purification, on a comparatively large scale, to the special needs of Army service, the features of the new outfits being mobility and such compactness in arrangement that a complete water purification plant and analytical laboratory are carried on the chassis of a 3-ton truck.

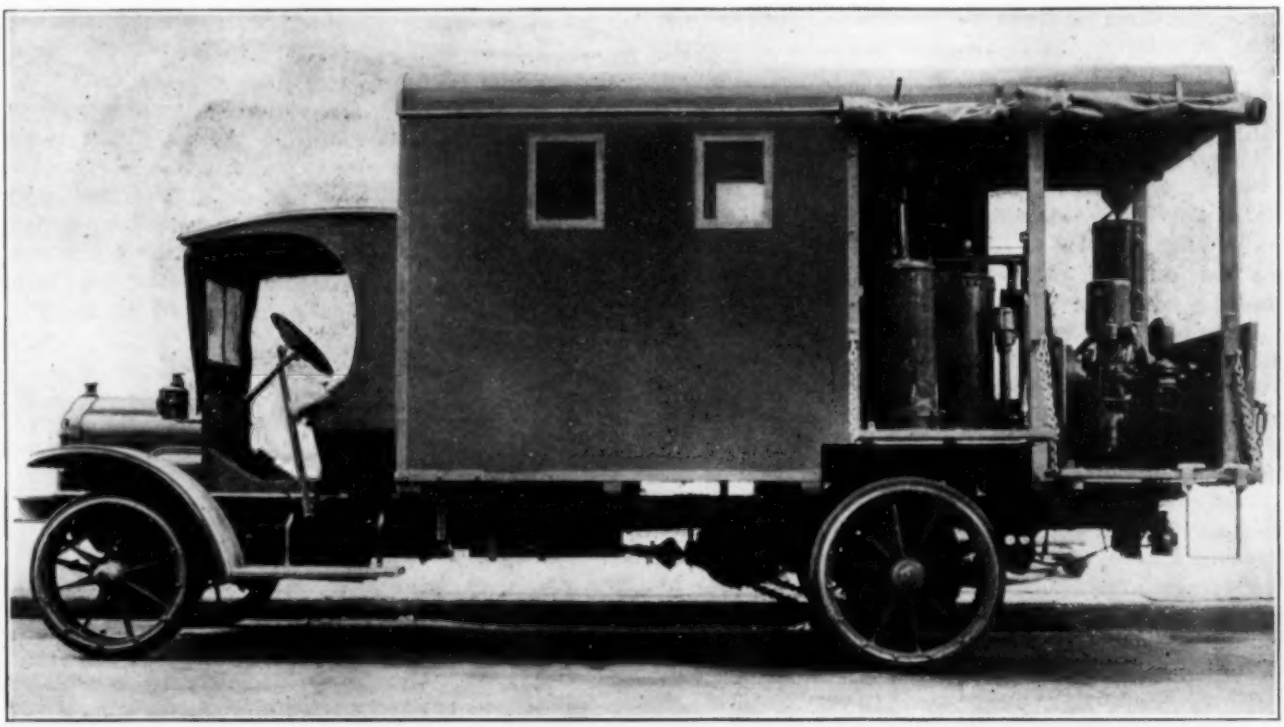
The details of the "Steri-Lab" truck are shown in the accompanying drawing and photographs. At the rear end is a gasoline-driven pump of the double-acting piston type with a rated capacity of 20 gal. per minute which may be operated against a pressure of 100 lb. per



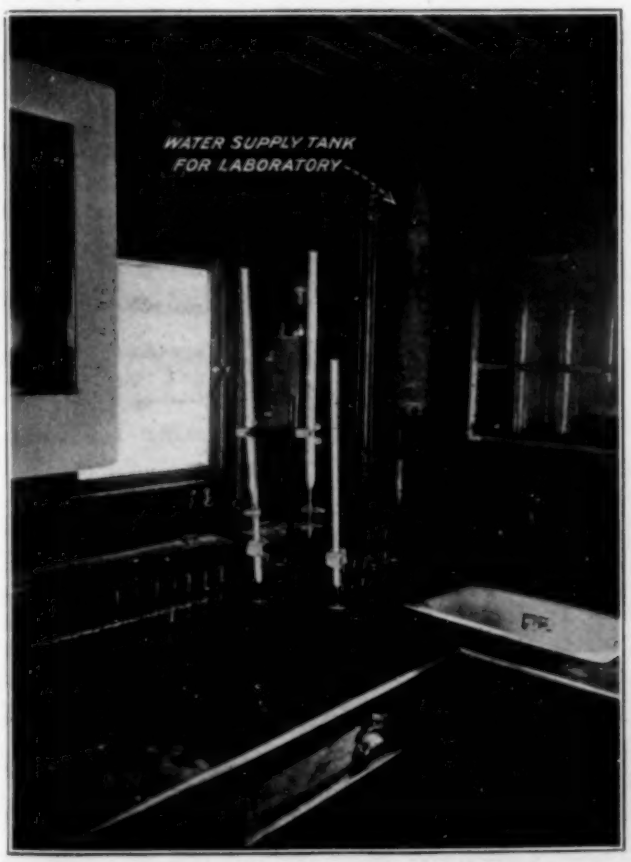
SIDE ELEVATION AND PLAN SHOW DETAIL OF MOBILE WATER-PURIFICATION PLANT

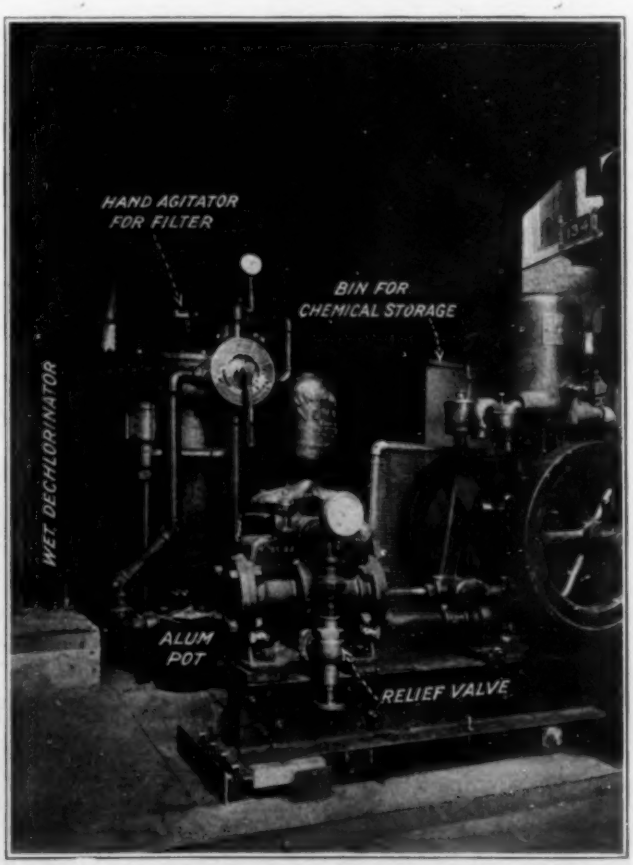
square inch. It is equipped with 50 ft. of 2-in. hose, foot-valve and strainer. The pump delivers direct to a Roberts mechanical filter of the pressure type, a 30-in. diameter vertical tank mounted over the rear axle. This filter has a hand agitator and is fitted with an alum pot. An alum storage bin is mounted over the right rear wheel of the truck.

There are at the present time three different types of these motor-truck plants. The first is known as the "Steri-Lab" and comprises a pump, a pressure filter, a



ALL THE STERI-LAB EQUIPMENT IS COMPACTLY ARRANGED AND CARRIED ON A THREE-TON TRUCK





CORNER OF WATER ANALYSIS LABORATORY—PUMPING PLANT, PRESSURE FILTER AND DECHLORINATOR

chlorinating apparatus and a laboratory. The second, the "Chloro-Pumping" outfit, is like the first, except that it carries no pressure filter, and has a pump of greater capacity than the "Steri-Lab." The third is essentially a laboratory on wheels for the chemical and bacterial analysis of water. These mobile plants were designed and equipped by the Wallace & Tiernan Co., Inc., of New York, working in collaboration with officers of the Corps.

Chlorine gas is applied at the pump suction, and the dose generally is much heavier than that employed in ordinary municipal water-works practice. It may vary from 4.5 to as much as 10 parts per million. A contact period of from 10 to 15 minutes is afforded by cylindrical tanks mounted under the work bench of the laboratory compartment of the outfit. With such an intensive application of chlorine, which is adopted to insure absolute safety in the quality of the treated water, it will frequently be necessary to dechlorinate with a thiosulphate solution applied through an adjustable sight feed. The chlorine is carried in 105-lb. cylinders. To a large extent our water-supply sterilization will be carried on with chlorine obtained from the gas service of the American Expeditionary Forces.

The filtered and sterilized water passes either to a discharge valve, where it can be fed to tank carts or stationary storage, or it may be left in the contact tanks for storage there. These four tanks have a capacity of 30 gal. each, and are tested for a pressure of 100 lb. per square inch.

The forward part of the truck body is occupied by the testing laboratory. This room is completely inclosed, and provided with a door from the rear and wire-glass windows on the side. It is completely equipped as a water-testing laboratory, with working bench, wash sink, water under pressure through faucets, hot air sttrilizer for sterilizing water, autoclave, etc.

This type of machine will be able to sterilize 1200 gal. of water per hour when operating through its full system. A bypass is provided around the filter, so that if a water supply is encountered which does not require filtration to remove turbidity and color, but simply chlorination to make the water bacteriologically safe, the capacity may be increased.

The second type of mobile plant, or "Chloro-Pumping" outfit, is carried on a 1½- instead of a 3-ton truck. Here there is no pressure filter. The pump has a capacity (40 gal. per minute) double that of the "Steri-Lab" machine. This outfit is designed for emergency work during an advance or a retreat where filtration may be dispensed with. The chlorinating and thiosulphate apparatus is of the same kind as that previously described.

The "laboratory," or third, type of truck is also carried on a 1½-ton chassis. It is fitted with the usual equipment for making chemical and bacteriological examinations of water. All racks and cases are felt-lined to prevent glass breakage. Water for laboratory use is contained in a tank fitted with a hand air pump to supply pressure. On this truck will be carried a bicycle for the use of the laboratory assistant in collecting samples.

Domestic Chrome Ore Supply Satisfactory

The War Industries Board announces through Mr. Hugh W. Sanford, chief of the ferro-alloys section of the chemicals division, that the situation with regard to chrome ore in United States is well in hand.

Washing in Filter Presses

By D. R. Sperry

Thorough Washing

THE most important and the most widely used method of washing employed in filter-presses is known as "thorough washing." This system of washing has also been called "every-other-plate system" from the fact that every other plate only has a wash inlet. "Back washing" is a term sometimes used because of the fact that the wash-water fills the space back of the cloths in contradistinction to simple washing where the wash-water enters between the cloths with the cake. "Through washing" has been used to denote this system probably from the incidence that the wash-water goes completely through the cake and both cloths. This term may also be a corruption of the word "thorough."

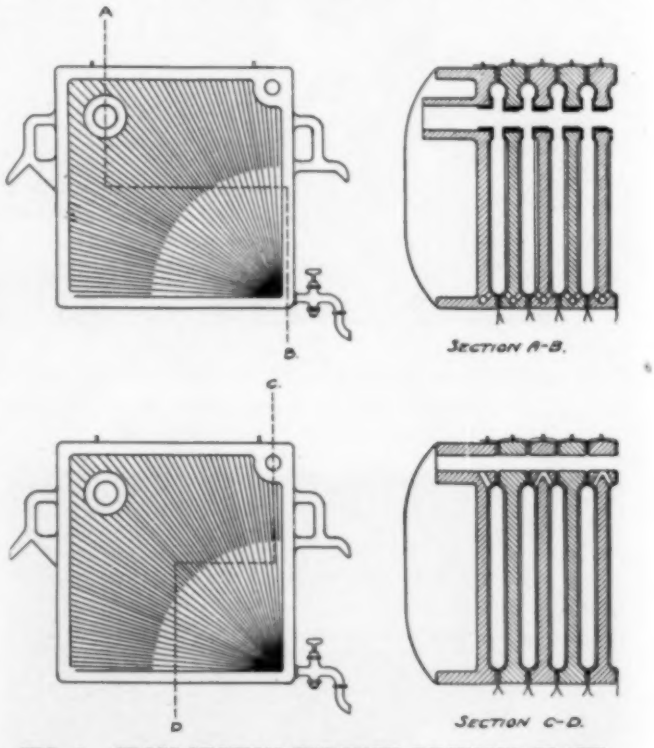


FIG. 1. CROSS-SECTION THROUGH RECESSED-PLATE FILTER-PRESS

Occasionally one hears the term "every-other-cock system," because in this system every other cock is closed.

Thorough-Washing in Recessed Plates

In thorough-washing two different kinds of plates are used in each arrangement. The two kinds of plates are placed alternately in the filter press. The difference between the two plates lies in the fact that one has an inlet from the wash eye to both surfaces while the other has no inlet whatever from the wash eye to the interior. These plates are distinguished from each other by the terms "wash plate" and "non-washing plate" respectively. Fig. 1 is a cross-section through a recessed-plate filter-press. The upper cross-section passes through the feed channel while the lower passes through the wash channel.

The plates are clothed in the usual manner and placed in the filter press, first a non-washing plate, next a washing plate, and so on until the filter-press is com-

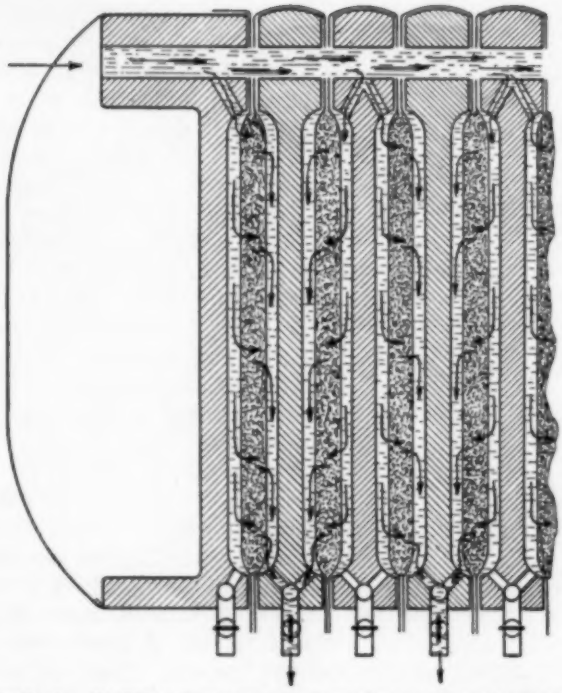


FIG. 2. PATH OF WATER IN THOROUGH-WASHING SYSTEM

pletely filled. In Fig. 1 the upper plate is a non-washing plate as there is no connection between the small upper-right-hand-corner eye and the interior of the plate. The lower is a washing plate because the small upper-right-hand eye has an inlet leading to both surfaces of the plate. In the thorough-washing system it should be borne in mind that the heads of a filter-press having an uneven number of plates are always different—one has an inlet from the washing channel and the other has not. Sometimes the stationary head is a wash-head, as shown in Fig. 1 (lower part), but it is just as likely to be a non-washing head depending upon the way the maker built the machine. In good practice, for reasons given later, filter-presses having an uneven number of plates have the stationary head, a washing-head, while if there is an uneven number of plates both heads are non-washing. However the heads may be, a non-washing plate must always come next to a washing-head as shown in Fig. 1, while a washing plate must always come in contact with a non-washing head. A head is non-washing if there is no connection between the wash eye and the surface of the head, while if there is such a connection as in Fig. 1, it is a washing-head. Filling of the filter-press is accomplished the same as was done in the plain recessed type, care being taken to see that the wash-inlet valve is closed and all cocks wide open. The material to be filtered, which is pumped into the feed inlet, fills all the chambers formed by the plate recesses. As the liquid flows through the cloths bounding the chambers, the solids left behind fill the chamber completely, forming a cake. At this point the feed-inlet valve is closed and the pressure allowed to fall to zero. The cocks on all the washing plates and heads are then closed. The wash-water valve is then opened and the wash-water allowed to issue from the non-washing plate cocks. A study of Fig. 1 lower cross-section, shows that the wash-eyes form a continuous channel from one end of the filter-press to the other. When wash-water is forced into this channel it drops into only every other plate—the washing plates. In so doing it fills the space between the filter-base or cloth and the plate surface on both sides of the plate. The wash-water cannot pass directly out of the filter-press through the cocks because they are all closed on the washing plates. This being the case there is no way for the wash-water to get out except by passing through the cloth, through the solids and through the cloth on the non-washing plate. This is done with the result that the wash-water, after passing through both cloths and cake, emerges against the surface of the non-washing plate and passes downward and out through the cocks which purposely were left open on the non-washing plates.

In Fig. 2 an enlarged cross-section shows the path of the wash-water as used in the thorough-washing system. It will be noticed that since the cake through which the water must pass is twice the thickness through which the filtrate passed, the wash-water pressure must be greater than that used in filling the filter-press. Further reference to the proper washing pressure is given farther on. It should also be noted that the washing pressure is equal on both sides of the washing plates so that there is no danger of breaking plates by wash-water pressure. The pressure on both sides of the non-washing plates is also equal.

In Fig. 3 is shown a photograph of a washing plate of the recessed type. The picture is not large enough

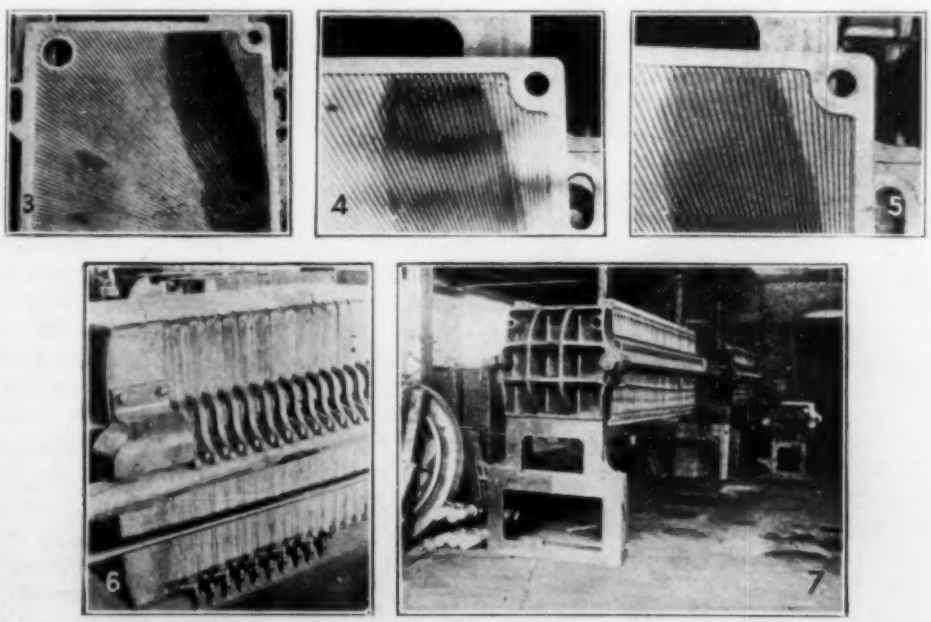


FIG. 3—RECESSED-TYPE WASHING PLATE. FIG. 4—WASHING PLATE. FIG. 5—NON-WASHING PLATE. FIG. 6—ARRANGEMENT OF COCKS FOR THOROUGH WASHING. FIG. 7—WASH AND FEED INLETS

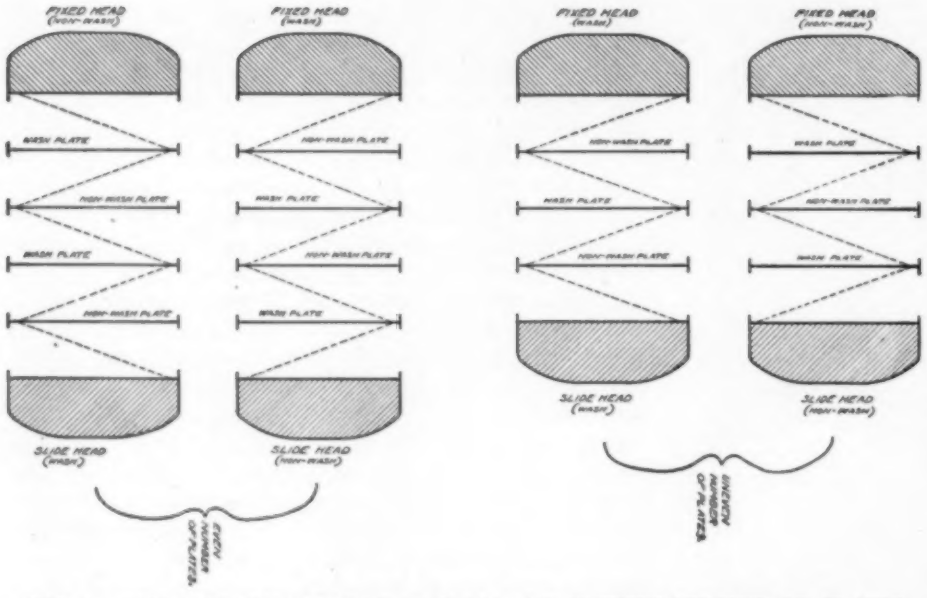


FIG. 8. PATHS OF WASH-WATER IN EVEN AND UNEVEN NUMBER OF PLATES

to show sufficient detail to distinguish whether or not there is an inlet from the wash part to the plate surface. If this plate were a washing plate a close-up photograph would disclose a wash-inlet as shown in Fig. 4. If, however, it were a non-washing plate the wash part would appear without an inlet to the plate surface as shown in Fig. 5. A photograph of a thorough-washing filter-press with the cocks arranged ready for washing is shown in Fig. 6. The wash and feed inlets of a wooden-plate thorough-washing filter press are shown in Fig. 7.

Washing and Non-Washing Heads

In Fig. 8 are two diagrams showing roughly the path of wash-water through filter-presses having, in the upper diagram, an uneven number of plates, and in the lower an even number of plates. In the case of an uneven number of plates it can be seen that neither head is a washing-head provided the stationary head is non-washing. On the other hand if the stationary head is made a washing-head, then both heads must be washing-heads. As it is more expensive to make a washing-head than a non-washing head, the first arrangement is best.

In the case of an uneven number of plates it can be seen that one head is always a washing-head. As it is less expensive to make the stationary head a washing-head than to make the movable head washing (due to the fact that it forms the end of the wash-channel) it is proper for an uneven number of plates to have the stationary head a washing-head.

Pressure in Washing

Since the flow through a filter-cake is non-sinuous,[1] in which the velocity of the liquid through the capillary paths varies directly as the pressure and inversely as the length of the channel (in this case thickness of cake), it would appear as though twice as much pressure would be required for the wash-water, since it flows through cake twice as thick as that passed through by the filtrate, providing a flow of wash-water is desired at least as great as that of the filtrate. In actual practice only 10 to 20 per cent greater pressure is required on the wash-water, in most cases, to produce a reasonable flow. In filling a filter-press the pressure is allowed to build up gradually until it reaches a predetermined maximum. This maximum pressure, if distributed over a cake one-half the thickness of the chamber would produce a flow far greater than that last observed issuing from the filter-press cocks. In the later stages of filling, the opposing cake surfaces gradually come in contact with each other, usually first at the bottom of the chamber and extending upward. The last bow, therefore, is from a restricted area and not from the large area covered by the wash-water; hence double the feeding pressure is not required on the wash-water to produce a good flow equal to that of the filtrate.

Batavia, Ill.

[1] The Principles of Filtration, by the author, in Metallurgical & Chemical Engineering, 15, 198-203 (1916) and 17, 161-166 (1917).

Fuller's Earth in 1917

The production of fuller's earth in 1917, as shown by a report published by the United States Geological Survey, Department of the Interior, was 72,870 short tons, valued at the mine at $776,632 or $10.66 a ton. The increase over 1916 was 5048 tons, or 7 per cent, and $69,681, or nearly 10 per cent. Since its beginning, in 1895, this industry has almost steadily increased until, in 1917, its output and the value and average price per ton of its product were the highest yet attained.

Fuller's earth is found in many States, but in 1917 it was mined and marketed in only six. Florida was the leading producer in 1917, having been credited with more than three-fourths of the total output and value. The other States, named in order of production, were Georgia, Texas, Massachusetts, Arkansas, and California. The Southern States produced 98 per cent of the domestic fuller's earth marketed in 1917. The imports of fuller's earth, 16,994 short tons, also increased in 1917, but they formed only 19 per cent of the consumption. A few of the prominent domestic producers are: Floridin Co., Quincy, Fla.; General Reduction Co., Dry Branch, Ga.; Lester Clay Co., Jacksonville, Fla.; John Olson, Benton, Ark.

The Present Status of Electric Brass Melting

In the article on this subject published in our issue for Sept. 15, page 321, several errors appear which affect the continuity of text. Line 17, column 2, page 324, should be followed by the matter appearing on line 10, column 1, page 327, to line 35, column 1, page 328, inclusive, which in turn should be followed by the matter from line 18, column 2, page 324, to line 9, column 1, page 327.

Recent Chemical and Metallurgical Patents

Removing Suspended TNT from Spent Acid.—In the general practice of the TNT plants, large storage tanks are used to hold the spent nitrating acid during a separation process, when the minute crystals of nitro toluol held in suspension in the acid gradually gather at the top. The specific density of the crystals approaches so nearly that of the acid that the bouyant force is slight and long standing is necessary before the crystals rise to the top. Mr. FREDERICK M. G. JOHNSON of Montreal, Canada, has received a patent on a rapid and safe process for making this separation: 1000 lb. of spent acid is introduced into a vessel, which is hermetically sealed, and a vacuum of 25 inches of mercury created in the vessel above the material. Immediately minute bubbles of gas commence to collect on the particles of TNT suspended in the acid; these bubbles are presumably due to the vapor pressure of the nitric acid being greater than its internal hydrostatic pressure, so that the vapors gather at all the liquid surfaces, and the particles are ballooned up at a rapid rate to the surface. The cleared acid is drawn off from the bottom of the vessel, and the ton sludge transfered to a smaller vessel and heated sufficiently to melt the the TNT and cause it to separate completely from the acid contained. With this method of separation, much less acid is kept in idle storage. (July 9—1,271.575.)

Production of Aluminium.—GEORGE GIULINI of Italy notes that in the reduction of alumina with carbon in an electric furnace but little metal is formed, the bulk of it remaining as oxide, plus some carbide and nitride. He therefore proposes to effect the reduction in an electric furnace under high vacuum, thus removing the carbon monoxide as rapidly as formed and preventing it from reacting with the vaporous metal as follows:

$$2Al + 3CO = Al_2O_3 + 3C.$$

The volatile metal is also quickly removed from the proximity of the reducing agent, and therefore carbides are not formed to a great extent. (1,257,995; Mar. 5, 1918.)

P. R. HERSHMAN of Chicago, Ill., patents the method of reducing alumina (especially in the presence of oxides such as SiO_2, which materially reduce its melting point) by carbides either introduced as such or formed in the furnace at temperatures below the reduction point of the alumina. He specifies that the proper mixture be pressed into such form as to make the resistor of an electric furnace, and that the gaseous products of the reaction be immediately withdrawn from the furnace. It is also necessary that the reaction be carried out in a reducing atmosphere, consisting of hydrogen or hydrocarbons, and that the resulting metal be tapped shortly after its formation. As an essential constituent of the resistor he adds small amounts of finely divided aluminium, copper or other heat-conducting metals. (1,273,-220; assigned to the Mineral Products Co.; July 23, 1918.)

Separating Nickel from Copper.—JOSEPH DHAVERNAS of New Brunswick, New Jersey, notes that when nickel-copper mattes are roasted to form copper oxides, which latter are to be removed by leaching, the removal of copper is never complete unless the roasting is sufficient to oxidize considerable quantities of the nickel as well. He therefore specifies that the roasting shall be followed by a reducing fusion, converting the mixture of oxides and sulphides into a low-sulphur matte containing considerable metallic materials. Nickels may now be removed from this mass by leaching with a slightly acid copper solution, any excess of copper remaining in the liquid being removed by precipitation on metallic nickel. (1,273,465; assigned to United States Nickel Co.; July 23, 1918.)

JULIUS H. GILLIS of Toronto, Canada, electrolyzes a nickel-sulphate solution, using a cathode of nickel and an anode of nickel-copper alloy containing about 60 per cent of the former metal. During the flow of the current, pure nickel at first deposits on the cathode, while copper and nickel both enter solution at the anode, the nickel in larger proportion owing to "selective action" and to the preponderance of this metal in the alloy. Before the copper ions have been transported any considerable distance from the surface of the anode, the current is reversed. Nickel now goes into solution from the plate formerly the cathode, while spongy copper will largely be deposited on the ertswhile anode. The deposited copper falls off and collects in the bottom of thetank as a slime. It is found that the slime also carries iron and other formerly troublesome metallic imprities. A diaphragm may be used to prevent the slime contaminating the nickel deposit. With about ten alternations of current per minute, the reverse current being held for perhaps two seconds, a substantially copper-free nickel deposit may be obtained. (1,260,661; assigned to British American Nickel Corporation, Ltd.; Mar. 26, 1918.)

Brick from Iron Blast Furnace Slag.—J. B. SHAW of Alfred, N. Y., notes that while excellent paving brick is being made from English blast furnaces, an equivalent product has not yet been made in the United States. British practice consists in pouring molten slag into split metal molds, removing the red hot bricks when they have solidified sufficiently to be handled without deformation, and placing them into kilns where they cool and anneal slowly.

These bricks have a "stony" texture, while American bricks made in a similar manner are glassy and brittle. Composition of the slag probably has a great deal to do with these conditions, the British slag containing 26 per cent silica and 22 per cent alumina, while here the corresponding amounts are 34 and 14. In practice, American slags quickly solidify with a thin, tender skin, retaining a molten interior for a considerable period. To make successful brick the author specifies that the hot mass must be immersed in red hot sand, or some other hot medium which effectually excludes air and furnace gases, in such a manner that the heat from the packing and the molten interior reheats the chilled shell into a very viscous substance. Further cooling must now be arranged so that the exterior and interior of the mass shall cool at about the same rate, from 12 to 18 hours being required for proper annealing. (1,259,304; Mar. 12, 1918.)

Synopsis of Recent Chemical and Metallurgical Literature

Zirconium, its Alloys and Oxide.—A paper followed by discussion on this rare element, especially its use as a refractory, was read at a meeting of the Birmingham (England) Metallurgical Society on March 14, 1918. Mr. LEOPOLD BRADFORD contributed the paper under discussion. It was remarked that the published material on zirconium and its compounds was so contradictory that it was difficult to know just what to believe. The metal has been recovered in amorphous, graphitic and crystalline form. The amorphous material, 97 per cent pure, produced by reducing potassium zircono-fluoride with sodium in the presence of sodium chloride in a bomb furnace might be converted into metal 99.8 per cent pure by forming it into electrodes and striking an arc in an atmosphere of hydrogen at reduced pressure. The metal resembled white cast iron, had a specific gravity of 6.4, a specific heat of 0.0804, and a melting point of 1530 deg. C. Amorphous zirconium is a bad electrical conductor and oxidizes readily, while the crystaline variety oxidizes only at white heat and is not affected by strong acids. Aluminium-zirconium alloys are easily produced and have about the same properties as aluminum-titanium alloys. Ferro-zirconium is easily produced by the thermit process, and alloys containing up to 35 per cent had been used to some extent as scavengers. Alloys containing as high as 90 per cent have been marketed in America. It is rumored that such material is used in Germany for making armor some three times as resistant to penetration as the ordinary armor-plate, but the production of such ferro-alloys in quantity by the electric furnace was not thought to be commercially feasible. A self-hardening tool steel consisting of nickel, cobalt and chromium together with from 2 to 40 per cent of zirconium has been proposed.

The oxide, zirconia, was by far the most important compound, however, and has been largely used as a refractory. The properties of the material used in this way has been fully treated by H. C. MEYER in METALLURGICAL AND CHEMICAL ENGINEERING, Vol. 12, p. 791 and Vol. 13, p. 263. Dr. WALTER ROSENHAIN found that rather impure zirconia (75 per cent) had a very considerable shrinkage, apparently increasing with the temperature, and therefore making it imperative that the refractory should be burnt at a higher temperature than it was to resist during use. The refractory properties were increased enormously on purification, however. Though pure zirconia alone when molded for the production of refractory articles such as crucibles were apt to crack and crumble, even though heated up gradually, these drawbacks could be overcome by fusing the oxide in the electric arc furnace. Fused zirconia had a high thermal endurance, and was not affected when heated to redness and plunged into cold water, as its co-efficient of expansion—0.00000084—was extremely low, near to that of quartz glass. Its resistance to crushing stress was many times greater than that of quartz glass. Fused zirconia, therefore, appeared to be a refractory of exceptional value. Its hardness was between that of corundum and that of quartz. It had a specific gravity of 5.89 and a porosity below 1 per cent. The melting point, as determined by PODSZUS, was 2,950 deg. C., but 0.5 per cent impurity reduced this by 100 deg.

Electrolysis of Lock Valves at Panama.—R. H. WHITEHEAD describes the corrosion taking place in the valves in the Panama Canal locks in the *Engineering News-Record*, June 27, 1918, V. 80, p. 1219. Fig. 1 shows the details of the valve chambers which have been giving the trouble. The valves control the flow of water in the 18-ft. culverts in the lock walls, and stop an opening 8 ft. wide by 18 ft. deep. During operation they are immersed in water more or less salty, although sea water is not necessary to set up the corrosive effects noted. It was thought that the valves would be replaced at intervals of ten years and that such replacement would be cheaper than to maintain protective coatings, but examination of several sets after less than two years' service shows very serious corrosion. Various metals are used in the construction—lead, babbitt, bronze, brass, steel and iron—of which steel is the most

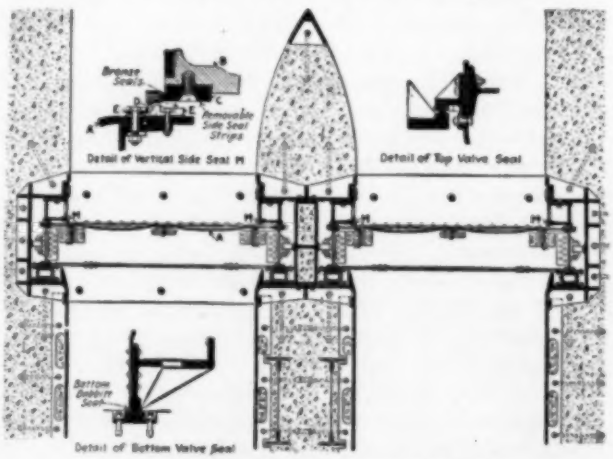

Bronze Seals
Removable Side Seal Strips
Detail of Vertical Side Seal
Detail of Top Valve Seal
Bottom Babbitt Seat
Detail of Bottom Valve Seat

FIG. 1.—DETAILS OF VALVE CHAMBER

electro-positive, with iron next in the list. The only attempt to nullify the galvanic action in the original installation was the placing of nine zinc electrodes in the lowest valves. Various paints and protective coatings were tested by coating a steel bar, immersing it in salt water with a dissimilar metal, and noting the curve traced with a recording millivoltmeter. None of the coatings showed a protection for longer than ten days except "bitumastic," which was accepted for the work. The bottom babbitt seat on which the valve rested had caused so much corrosion that it was necessary to plane off the bottom of the valve, and the babbitt was replaced with greenheart. The removable side steel strips had been so badly corroded that the leakage had increased to nine times normal; therefore they were replaced with lignum vitae. The lead used in caulking fixed irons and leading-in bolts was replaced by cement, zinc electrodes placed at the bottom of the bronze seals and all parts except rubbing surfaces coated with "bitumastic." Pipes were led to the bottom of the roller trains at the side of the valves, through which crude oil will be forced. This oil is expected to adhere to the uncoated rubbing-parts as it rises through the water, thus protecting them from corrosion. The roller train rods and valve stems which pass through water-tight stuffing boxes of brass are corroding at a rate which will require renewal in three years.

Corindite, a New Refractory.—ALEXANDRE BIGOT, Engineer to the French Ministry of Armaments, described a new aluminous refractory at the meeting of the British Ceramic Society held May 14, 1918. The material used in its manufacture is either the white, high silica bauxite, or the red, high iron bauxite so common in the south of France. The method of burning the material has been patented by the late M. Noel Lecesne, and consists in heating a mixture of bauxite and anthracite in a cupola using forced draft. During the process a considerable portion of the aluminium is reduced to the carbide, but this is reoxidized by the oxygen in the blast to alumina. At the end of the heat there remains a vesicular block fused in successive layers, containing a large number of small alumina crystals. After removal of magnetic metallics, this so-called "corindite" has the following analysis:

	White bauxite fused.	Red bauxite fused.	Naxos emery.
Alumina	68.80	69.25	69.46
Titanic oxide	3.85	3.70	....
Silica	21.40	3.00	2.41
Iron oxide	5.25	23.35	19.08
Carbon	0.60	0.50	....
Lime	....	....	2.18
Loss on ignition	0.10	0.15	....
Combined water	....	....	5.47

Corindite cones start to melt at 1950 deg. C., being more refractory than the original bauxite. This is because most of the original ferrous iron has combined to form spinels, $Al_2O_3.FeO$. Binders containing lime and magnesia must be avoided, bauxite and kaolin being preferred. Hand made bricks contract 2 per cent in drying; machine made bricks dry with constant volume. During the normal burning to 1400 deg. C. there is no apparent shrinkage. Between 1700 and 1735 deg. C. bricks expand about 0.5 per cent, and from that point to 1850 they contract 3 per cent. These brick resist wear from three to four times as well as the best magnesite bricks, and a lining in a cement kiln lasts twice as long as one made from unfused bauxite. Corindite is attacked by slag and scoria in the same way as bauxite brick.

The Swiss Kiln for Deadburning Magnesite.—Two Swiss engineers, STEIGER and FREY, have erected a continuous vertical kiln for the dead-burning of magnesite on the island of Euboea, Greece, which has been in successful operation eighteen months. The output of the natural-draft kiln which the new kiln was designed to supplant was 4 tons of calcined material per day. The new kiln averages 14 tons per day, with a fuel consumption of 20 per cent, as compared to 35 per cent for the old. The new kiln requires 30 horsepower for driving the moving parts. It consists of a vertical chamber, lined with magnesite brick. Magnesite rock is automatically elevated to the top and charged continually through a bell. It gradually descends against hot gases, passing through the hottest zone, and thence into the cooling zone. The bottom of the shaft is closed by a flat conical casting, ribbed on top. Rotation of this casting at the rate of about two per hour delivers the finished material to the discharge chute and tends to break any lumps formed in the burning. Heating is effected by artificial gas delivered hot from a producer alongside and burned in air delivered under pressure. A temperature of 1700 deg. C. (approximately that of the open hearth furnace) is effected when using a good grade of coal. The gases are drawn from the top by a suction fan, leaving the furnace at about 150 deg. C. The designer, E. Steiger, who described the installation at the May meeting of the British Ceramic Society, believes that its fuel economy may commend it to those who are calcining and burning various materials in the less efficient rotary kiln.

Ray Materials for Silica Products.—*The Iron and Coal Trades Review* for May 17, 1918, contains an article by A. BIGOT, Consulting Engineer to the French Ministry of Armaments and Munitions, on the raw materials entering into the manufacture of silica refractories. The author recommends close analytical studies of the quartzites used. He finds that a natural rock analyzing 95.95 per cent SiO_2, 2.65 per cent Al_2O_3 and 1.96 per cent FeO shows under the microscope that the quartz crystals were surrounded with amorphous matter. On very fine grinding (through 200 mesh) and water classification, the lighter fraction was found on analysis to have an alumina content of 7.6 per cent, which corresponds to a clay content of 22 per cent. This finest material is rather plastic, and is more fusible than the original rock. The grinding of such a quartzite would set free the entrapped clay, which in the presence of the fine quartz particles and a small amount of lime forms a plastic mass which begins to vitrify and contract at 1250 deg. C., enveloping the quartzite grains and forming the correct bond. Therefore, a study of the natural binding material contained in massive quartzites should be completed to obtain intelligent bonding.

A most important physical test consists in taking a piece of the quartzite weighing about 100 grams, heating it gradually to 1710 deg. C., holding it at that temperature for one hour, and cooling in the furnace. During this time the rock has reached its maximum expansion, and the appearance after the test gives much information. Rocks containing alkalies or an excess of alumina are fused, and are therefore unsuitable for use as a silicious refractory. Some remain compact, preserve their shape, but present a few cracks, or in other cases split into a number of fairly large pieces. If the pieces themselves are tough and compact and of moderate size they are suitable for use in refractories. If the rock breaks into very small pieces, or granulate as do certain sandstones, the friability of the grains renders them unfit for use. Many sandstones act perfectly until a temperature of 1600 deg. C. is passed, rapidly disintegrating at 1700 deg. Flints usually break into large, tough pieces, which would seem to be ideal for the manufacture of bricks, but as a matter of fact, they contain so little natural clayey bond as to give unsatisfactory results. The author believes that the perfection of microscopic technology will soon enable one to determine the cause of the variable expansion of similar quartzites, ranging from 9 to 15 per cent. Exposure to high temperature changes quartz into cristobalite and into tridymite, with increase in volume. At the same time, the crystals are traversed by microscopic cracks, the number and size of which may determine the total expansion of the rock.

Quantitative Determination of Suspended Tarry Matter in Gas

By F. W. Steere

THE problem of making quantitative determinations of the suspended matter carried by coal retort gases has in the past given no end of trouble. The writer has tried every scheme suggested in technical papers, but found them not sufficiently reliable or too complicated for practical use.

The problem was solved for our own work by developing a suggestion found in the 1909 "Wrinkles" of the American Gas Institute. The method was worked

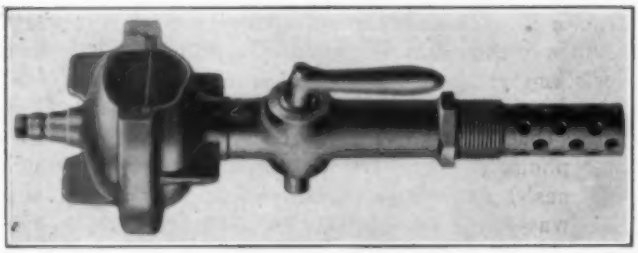


FIG. 1. VIEW OF TAR CAMERA SHOWING TEST PAPER ENCLOSED BETWEEN CASKETS.

out for determining the quantity of tar carried by coal gas at the different stages of condensation, but has also been found equally valuable for determining the quantity of suspended matter carried by any gas or the atmosphere. We have called the apparatus a tar camera because of the colored stain left on the filter paper by the tar taken from the sample of the coal gas under test. The tar camera does not eliminate gas plant trouble, but it does furnish a simple means of detecting it and studying its causes. How much tar does your gas carry on entering the ammonia scrubber? How much tar does it carry into the purifier? How do you know whether your tar extractor is working up to standard? As vital as these questions are—the number of plants that regularly make these determinations is almost negligible.

In plants subject to napthalene trouble, it is especially important that a close watch be kept on the quantity of light tars carried into the ammonia scrubber. These tars are saturated with napthalene when they enter the ammonia scrubber and come in contact with the ammoniacal scrubbing liquor. Phenols are dissolved out of the tar by the ammonia, forming salts more soluble in water than the phenols. The phenols are very good solvents of napthalene. The inevitable result, therefore, when phenols are dissolved out of the tar, is to supersaturate the gas with the napthalene set free.

This is the reason that gas tested after the ammonia scrubber shows more napthalene than the gas entering the scrubber. The answer is to keep the quantity of tar carried by the gas at this point—a minimum. As a further illustration of the many problems that may be studied by the tar camera, consider the increased life of the purifying sponge if it were not fouled with light tars.

The Tar Camera and Its Application

The tar comera is so called because it is used to take "tar pictures"—a tar picture being a piece of special white paper through which a certain amount of gas has been drawn. The tar carried by the gas leaves a characteristic stain on the paper and the amount of it can be determined either by comparison with a standard paper, or much more accurately, by weighing the paper before and after taking the picture.

The construction of the tar camera is well shown in the illustration, Fig. 1. It is made entirely of aluminium—including the cock. Aluminium wil not corrode or be affected by any of the constituents of the gas.

Where the gas is under pressure, it is only necessary to screw the tar camera into the pipe line or apparatus at the point to be tested. The outlet of the camera is connected to the test meter, or measuring bottles, with rubber tubing, Fig. 2.

When the gas is under vacuum, it is usually simplest to use aspirators. If standard aspirator bottles of one or one-half cu.ft. capacity are used, the test meter is not necessary as the gas is measured as it is drawn into the aspirator. These aspirator bottles can be used in place of the test meter for measuring the gas when it is under pressure, as is illustrated in Fig. 3.

In long series of tests where a great number of pictures are to be taken with the gas under vacuum, the best arrangement is to connect the tar camera through a test meter and then tap into a point in the system

FIG. 2. TAR CAMERA ATTACHED IN CIRCUIT WITH METER

which is under a greater vacuum than that being tested. In this way, pictures can be taken very rapidly and accurately.

The following points must be observed to insure accuracy:

Run trial pictures to determine the number of papers necessary—See paragraph "Number of Test Papers" below.

Blow out the connections after each test. If

napthalene crystals appear on the paper, swab out the connections between each test.

The connection between the tar camera and the apparatus must be as short as possible, otherwise tar

FIG. 3. TAR CAMERA IN CIRCUIT WITH ASPIRATOR

will be deposited in the connections and the results will be incorrect.

Always fully open the cock below the camera. If the gas is "wiredrawn" at this point, tar will be deposited after the cock and the test paper will not show the correct amount.

If the gas pressure is so great that the test papers burst on opening the cock full, then it will be necessary to place a small cock in the hose line leading to the test meter to limit the rate of flow. Always pinch the rubber tubing after the tar camera while the cock is being opened, then let the flow gradually increase.

The proper amount of gas to be used in a test is either one cubic foot or ten cubic feet. For very tarry gas (foul main, etc.) it may not be possible to get one cubic foot through the paper. Stop the test and read the meter when the flow has nearly stopped. For very clean gas (after purifiers, etc.) a better idea of the quantity of tar in the gas can be had by running a larger sample, but it is seldom necessary to run more than ten cubic feet.

Number of Test Papers To Be Used In a Test

Tar in a finely divided state will not all be stopped by the first paper, but will go on through and stain the next one and sometimes four or five layers. Two is the number usually used for routine work, but where the papers are to be weighed to determine accurately the amount of tar, not less than four should be used. Tests show that when the tar is light and penetrates several papers, in general, 70 per cent will be retained by the first paper, 25 per cent by the second, 3 per cent by the third, and 2 per cent by the fourth. But this is not, by any means, a hard and fast rule.

Colorimetric Method of Estimating Tar Carried By Gas

We have found that there is a rough relation with a given type of gas between the shade of tar stain and its weight. It is therefore possible to approximate the quantity of tar in the gas by comparing the stain with a standard.

Such a method depends largely on the observer's skill and ability in comparing the color shades. This method is not reliable when the amount of tar is so great that the paper no longer shows through. This condition is reached when a 1-cu.ft. sample contains about 50 milligrams of tar (equivalent to 110 lb. per million cubic feet).

If the amount of tar in the gas exceeds 100 lb. per million, then it is best to take a small sample of $\frac{1}{2}$ cu.ft. or $\frac{1}{5}$ cu.ft. for comparison. Also it is difficult to estimate extremely small amounts of tar by this method, except by taking larger samples (10 cu.ft.). Two milligrams of tar in a 1-cu.ft. sample (4.4 lb. per million) will leave a very light stain on the paper.

It must be remembered that retort gas, water gas and producer gas all give different stains, and the shade of the stain from any kind of gas will be largely influenced by the amount of free carbon it carries. Retort gas usually gives a light brown stain, turning darker after exposure to the air. Producer gas usually runs darker. Water gas tar may be very light on account of the presence of carburetting oil. Therefore the density

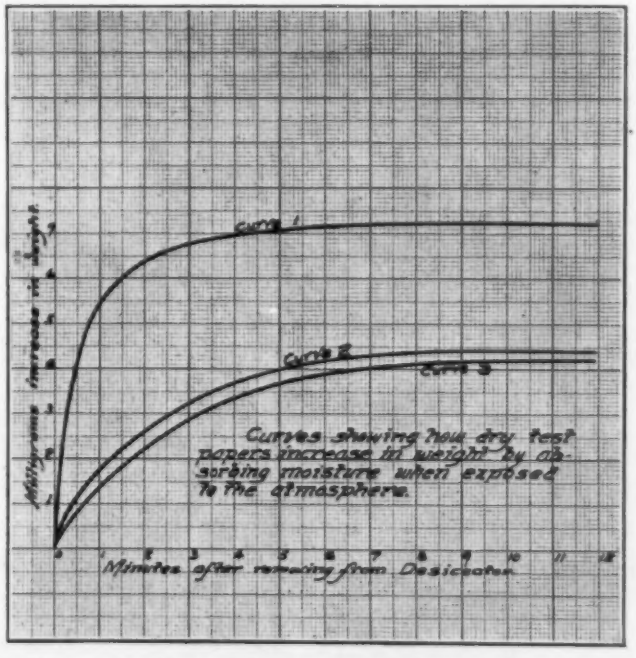

Curve 1
Curve 2
Curve 3
Curves showing how dry test papers increase in weight by absorbing moisture when exposed to the atmosphere.
Minutes after removing from Desiccator.

FIG. 4. RATE OF ABSORPTION OF MOISTURE BY PAPER

of the picture must be given consideration as well as the shade.

The amount of tar that is carried by gas will vary from about 800 lb. per million cu.ft. (5.6 grains per cu.ft.) or (362.4 milligrams per cu.ft.) down to clean

gas. We prefer to report tar in lb. per million cu.ft. This can be readily reduced to gallons per ton of coal.

Tar weighs approximately 8½ lb. per gallon. Retort gas runs aproximately 10,000 cu.ft. per ton of coal carbonized. Producer gas runs approximately 120,000 cu.ft. per ton of coal. The weight of tar on a test paper is best reported in milligrams. If the tar in a 1-cu.ft. sample weighs 1 milligram, this is equivalent to 2.2 lb. per million cu.ft.

The colorimetric tests are not designed for accurate quantitative results—their value is rather roughly comparative. They will show any appreciable increase or decrease in the quantity of tar vapor present. They also indicate relatively the quality of the tar—which

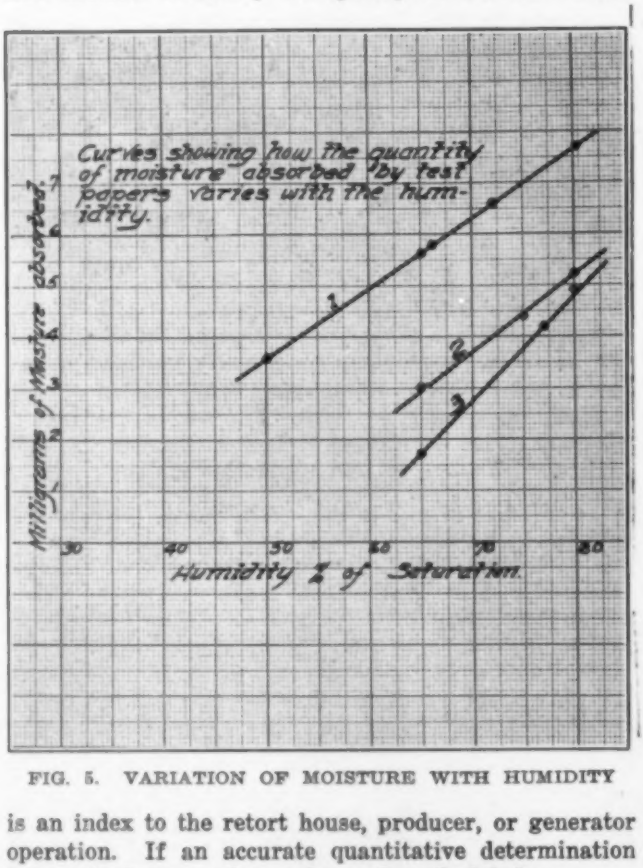

Curves showing how the quantity of moisture absorbed by test papers varies with the humidity.
Milligrams of Moisture absorbed.
Humidity % of Saturation.
1
2
3

FIG. 5. VARIATION OF MOISTURE WITH HUMIDITY

is an index to the retort house, producer, or generator operation. If an accurate quantitative determination is required, it can be made as described below.

Gravimetric Determination and Corrections

For weighing test papers, nothing but a good chemical balance can be used. A 3-inch filter paper commonly weighs about 280 milligrams (0.01 oz.) and the tar collected on it often weighs as little as 1 milligram (0.000035 oz.), or even less. Even if a suitable balance is available, the correct weighing of a test paper is not by any means a simple procedure.

A dry 3-inch filter paper will absorb as much as 7 milligrams of moisture from the atmosphere. The amount of moisture absorbed depends upon the humidity of the air, and somewhat on the temperature. It will not absorb as much moisture after being saturated with tar as it will when clean, and therefore the error due to moisture cannot be corrected readily.

To show the great difficulty of getting the correct weight of a test paper, we give below several curves showing the gain in weight of a test paper taken from a dessicator and placed on the pan of the balance. Fig. 4 shows a set of curves giving the rate of absorption of moisture by paper at 85 deg. F.; 77 per cent humidity. Curve 1 is for a clean paper 3 inches in diameter, weighing 260 milligrams when dry and clean. Curve 2 is for a 3-inch paper weighing 280 milligrams when dry, but loaded with 8 milligrams of tar. Curve 3 is for a 3-inch paper weighing 289 milligrams when dry, but loaded with 59 milligrams of tar. It will be seen that the clean paper increased 5½ milligrams during the first minute it was on the scale. Even if the weighing could be accomplished in ½ minute, this would mean an error amounting to 6 lb. of tar per million cubic feet—entirely too much to neglect.

The curve shows that in 8 to 10 minutes the weights become steady, but, unfortunately, the curves for the clean and tar-covered papers are not alike.

The curves in Fig. 5 shows how the weights are affected by humidity. Curve 1 is for the clean paper mentioned above. Curve 2 is for the paper treated with 8 milligrams of tar. Curve 3 is for the paper saturated with 59 milligrams of tar.

These curves show that the weight of a 3-inch paper changes about 1 milligram for each 7.3 per cent change in the humidity. As the humidity is likely to vary from 50 per cent up to 75 per cent during a single day, it will be seen how hopeless it would be to try to weigh test papers under atmospheric conditions.

The only accurate method of getting the correct weight is to do the weighing in a perfectly dry atmosphere. Drying out the interior of the balance case (with pans of calcium chloride) does not reduce the humidity much below 50 per cent and opening the door to put in a test paper or change weights, alters the humidity at once.

We have therefore found it necessary to provide other means of weighing test papers in a perfectly dry atmosphere, and experience has shown that this eliminates both of these errors and makes possible a very accurate result.

The Steere Engineering Co. is prepared to furnish tar cameras and test papers weighed according to its special methods. The weighed papers are put up in packages of 12 each, with the weight of each paper marked on the envelope. After taking the tar samples, the papers may be returned to it for accurate reweighing.

Mechanical and Electrostatic Detarring Processes

The problem of completely separating the condensed tar vapors from coal gas has probably received more study and met with less success than any other step in the manufacture of artificial gas. All public utility gas plant operators are familiar with the "P. & A." tar extractor in its many modifications. Extractors working on the principle of the submersion washer are also very numerous. These types of apparatus, although a long way from being perfect, will, when properly operated, clean retort gas and carburetted water gas sufficiently for commercial operation.

On producer gas, however, these types of apparatus are entirely inadequate. The detarring of producer gas requires much more strenuous treatment. This fact is clearly proven in that the efforts of the past twenty-five years have brought on the market detarring apparatus of an entirely different type than that used

by retort gas plants. Producer gas detarring apparatus may be roughly divided into two classes—apparatus based on compression, wire drawing and sudden expansion, and apparatus of the rotary type, into which water is sprayed. None of these devices have proved satisfactory, and the power and maintenance charges make them almost prohibitive. It is evident to both operators and experimenters that these methods of attack are wrong.

Contrasted with these mechanical methods of tar extraction, we have approached the problem from an entirely new angle. The Steere electrical detarring process[1] consists in simply passing the gas through a zone of high-tension alternating current. The high-tension discharges completely precipitate all of the condensed tar vapor.

The great advantages of the electrical process are in its extreme simplicity and complete effectiveness. The power cost is practically negligible. This process also opens up a great many possibilities in the manufacture of coal gas which, with the old methods of condensation and detarring, do not exist.

Detroit, Mich.

Pyrotechnic Smoke Signals

The Inventions Board, General Staff, Army War College, Washington, D. C., is desirous of receiving ideas and suggestions relative to the production of suitable material for smoke signals. The following information on the subject is given for the benefit of those who may wish to experiment along this line. Communications should be addressed to the Inventions Board as given above.

It is desired to secure, if possible, a suitable chemical substitute for red Saxony arsenic now used for the manufacture of yellow smoke signals. The characteristics of such a chemical are that it should produce the effect required, that it should be procurable in large quantities, and that it should be perfectly stable in combination with other chemicals, such as potassium chlorate. The effect desired is a rather deep orange yellow. There is no objection to the use of dyes should these give the effect required and be procurable in large quantities at a reasonable price.

A suitable formula for a red smoke signal is also a desideratum. The effect required is a pronounced and positive shade of red. As in the case of the yellow smoke signal, chemicals composing it should be readily procurable and should be stable. Since, however, the requirements for this signal are considerably smaller than for the yellow smoke signal a greater latitude may be allowed in selecting slightly less readily available and higher priced material for this signal.

The smoke signals outlined above are displayed from rockets, Very cartridges, Viven-Bessiere cartridges and 35 M/M cartridges. The rockets now used by our forces weigh about two pounds with an approximate length of eighteen inches. The V-B, Very cartridges and 35 M/M cartridges have an average length of about six inches with a diameter respectively of two inches, 25 M/M and 35 M/M. The V-B cartridges are thrown from the rifle grenade discharger, and the Very cartridges and 35 M/M cartridges from the 25 M/M signal pistols.

[1]Proceedings of the American Gas Institute, 1914.

Should any person accredited by the Inventions Board become interested in the two pistols outlined above, this office would be very glad to give all the information in its possession.

It should be noted that "auramine" has already been tried as a dye for the yellow smoke signal and that "paratoner" has been used in the red smoke signal.

Quicksilver Production in First Half of 1918

The production of quicksilver in the United States during the first half of 1918 was 17,576 flasks, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior. The total production in 1917 was 35,954 flasks, and as one-half of this is 17,977 flasks, the quantity thus far produced this year falls short by 401 flasks of that which should have been produced if the output this year is to equal that of last. As quicksilver, if not absolutely essential to the conduct of war, is a metal for which it would be exceedingly difficult to find satisfactory substitutes in all of its uses, and as an output of 36,000 flasks would, it is estimated, be barely enough to meet the demands in this country in 1918, the shortage indicated by the returns for the first half of the year calls for energetic efforts by the producers, the consumers, and the Government to increase the supply of the metal and to curtail less essential uses. With the enlargement of our Army the demand for quicksilver is likely to be considerably greater in 1919 than in 1918, and the perfection of satisfactory detonators for high explosives that shall contain little or no mercury is one of the urgent problems of chemistry as applied to war.

The decline in production during the first half of 1918 was due chiefly to the shortage and the increased cost of labor and to the exhaustion or depletion of known ore bodies under the stimulus of high prices for the metal. The practice at some of the larger mines has been to devote nearly all energy to getting out ore and to postpone the underground exploration and development that are necessary to insure long-continued steady production. In the language of the miners, some of the mines have been "gutted," and considerable time will be needed to restore them to a condition of high productivity. On the other hand, the high price of quicksilver has not led as extensively as had been hoped to the reopening of old mines long idle, although there are some notable examples of this result, and, during the second half of the year, these reopened mines may make good the shortage. Quicksilver mining is full of uncertainties, and capitalists are slow to invest extensively in an undertaking whose future can be so little foreseen. There is opportunity here for patriotism to cast the deciding vote where the cold doctrine of chances might turn the investor to industries offering greater assurance of reward.

One of the notable achievements in the industry during the year has been the successful adaptation of the rotary cement kiln to quicksilver metallurgy. Eight of these furnaces are now or will soon be in operation in California, and they are expected to make an increase in production that may more than offset the falling off during the first half of the year.

Personal

MR. M. H. BARNES, formerly chemist for the Illinois Steel Co., Gary, Ind., is now division inspector for the Aluminum Company of America, Maryville, Tenn.

DR. W. M. BURTON has been elected president of the Standard Oil Co. of Indiana to succeed the late Lauren J. Drake. Dr. Burton was recently awarded the Walter Gibbs medal of the American Chemical Society in recognition of his original work in the chemistry of petroleum, and as the discoverer of the so-called Burton process for producing gasoline.

MR. NORMAN CARMICHAEL is serving as chairman of the United War Work Campaign at Phoenix, Arizona.

MR W. W. COLEMAN and T. H. SYMINGTON have been appointed as special assistants to the Chief of Ordnance. Mr. Coleman will have charge of the production of cannon, carriages, and their appurtenances and accessories. Mr. Symington will have charge of artillery ammunition, metal components, but will have nothing to do with the loading plant operation.

MR. STUART CROASDALE announces the change of his business address to 730 Symes Building, Denver, Col., where he will continue his practice as consulting engineer in mining, metallurgy and industrial chemistry.

DR. RUDOLF GAHL has opened a consulting office in the First National Bank Building, Denver, Col., where he will continue to specialize in hydrometallurgy of copper ores, the design of new plants and the solution of operating problems in copper mills. Dr. Gahl was formerly connected with an Arizona copper company.

MR. H. C. PARMELEE, Editor of CHEMICAL AND METALLURGICAL ENGINEERING, has gone abroad on invitation of the British Government to visit England and France. He is one of a party of fifteen editors of business magazines who will be the guests of the British Government for about two months, returning to the United States late in December. The purpose of the trip is to facilitate the interchange of thought and opinion between the allied nations.

Obituary

MR. EDWARD J. DITTUS, Denver, Col., died at his home Oct. 11, 1918, of pneumonia, following an attack of influenza. Mr. Dittus was a graduate of the Colorado School of Mines and for several years after his graduation was assistant in the department of metallurgy at Golden. Recently he had been employed on potash production at Alliance, Neb., where he was taken sick. He is survived by a wife and child.

DR. ERNEST G. GENOUD died on Oct. 12, 1918, of pneumonia following an attack of influenza. He was born Feb. 23, 1889, graduated from the Massachusetts Institute of Technology, 1908, studied at Charlottenburg and Berlin, achieving his doctorate Jan. 15, 1911. He addressed himself more particularly to processes of fermentation and to special researches in regard to yeasts and other micro-organisms. For several years he had been engaged in technological research in the laboratory of Arthur D. Little, Inc., Cambridge, Mass. An article by him on "The Use of Micro-Organisms in Chemical Industry" appeared in our issue of Oct. 15.

PROFESSOR F. P. TREADWELL of Zürich, Switzerland, died suddenly of heart disease on June 25, 1918. Professor Treadwell was born at Portsmouth, N. H., in 1857. In the early seventies he attended school at Heidelberg, and later was lecture assistant there from 1878 to 1881 under Bunsen. His subsequent professional service was in the Eidgenössiche Polytechnicum in Zürich. His excellent textbooks on chemistry are widely used and his loss will be felt among chemists.

Current Market Reports

The Non-Ferrous Metal Market

Tuesday, Oct. 22.—Due to the control of the prices of metals by the War Industries Board, the market has generally reflected none of the varying political conditions due to peace talk and has great stability.

Aluminium:—The Government prices on ingots 98 to 99 per cent Al are $660 a ton f.o.b. plant in 50-ton lots; $662 down to 15-ton lots; and $666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

Antimony:—There seems to be an overproduction of antimony and prices are tending to decline in spite of the closing down of the French North African mines. Small quantities range from 13½c. to 13¾c. per pound.

Chrome:—Western production is now in slight excess of demand. The nominal quotation for 40 per cent ore is $1.40 per unit, while 50 per cent ore is bringing $1.70.

Copper:—The price of $520 per ton for car load lots and 27.3c. per pound for small quantities is expected to be continued for another period at the conference to be held on Oct. 25 in Washington.

Copper sheets, hot rolled	lb.	$0.36 —	$0.37½
Copper sheets, cold rolled	lb.	.37 —	.38½
Copper bottoms	lb.	.44 —	.45½
Copper rods	lb.	.36 —	.37
Copper wire	lb.	.29½ —	...
High brass wire	lb.	.28½ —	.29½
High brass sheets	lb.	.28½ —	.29½
High brass rods	lb.	.26½ —	.28½
Low brass wire	lb.	.32½ —	.34½
Low brass sheets	lb.	.32½ —	.34½
Low brass rods	lb.	.33½ —	.35½
Brazed brass tubing	lb.	.37 —	.39
Brazed bronze tubing	lb.	.42½ —	.44½
Seamless copper tubing	lb.	.41 —	.43
Seamless bronze tubing	lb.	.45 —	.46
Seamless brass tubing	lb.	.37½ —	.39½
Bronze (gold) powder	lb.	1.00 —	1.75

Lead:—The lead market is limited by selling restrictions, the supply being allocated by the Lead Committee. In car load lots at East St. Louis, the price is $155 per ton. In New York, all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.05c. to legitimate consumers.

Manganese:—The scale prices on page 629 of CHEMICAL & METALLURGICAL ENGINEERING, June 15, prevail; the highest price per unit being $1.35.

Silver:—The Government price of $1.01⅛ is hoped to promote production.

Tin:—The Tin Committee of the American Iron and Steel Institute has not yet announced the official price on tin. No doubt an understanding will have to be had with the producers before a final statement can be made public and as they are all in distant foreign countries, considerable time will elapse in intercommunication. During the first two weeks of this month about 1700 tons were imported. The price is about 78c. per lb. and is expected to decline.

Tungsten:—The Western producers of scheelite are reluctant in offering at $26 per unit. High grade wolframite is bringing $25. Off-grade ores vary from $20 to $24.

Zinc:—Spelter is tending to decline slightly. East St. Louis is quoting $173 per ton for October delivery and $170 for November and December. New York spot is 8.85c. to 9c. per lb.; sheet zinc, 15c., and zinc dust (300 mesh), 16c. per lb. in 1600-lb. casks.

OTHER METALS

Bismuth	lb.	$3.50 —	$3.65
Cadmium	lb.	1.50 —	...
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury .75	lb.	125.00 —	...
Mercury	lb.	1.95 —	...
Nickel	lb.	.40 —	.43
Tungsten	lb.	24.00 —	...
Iridium	oz.	175.00 —	...
Palladium	oz.	135.00 —	...
Platinum	oz.	105.00 —	...

The Iron and Steel Market

While the actual reports are not available, production of pig iron during October is believed to have been at a slightly better rate than the greatly improved rate shown for September, while production of steel is believed to have been

at about the September rate. The actual tonnage will show an increase, on account of October having 27 working days against 25 for September. The epidemic of Spanish influenza has affected the working forces at many plants, while others have practically escaped. The highest percentage of idleness was shown at the Duquesne Steel Works, where for some time about 750 men, or about 15 per cent. of the regular working force of 5100 men, were off, chiefly on account of the epidemic. At the various plants affected production was curtailed to a much less extent than would have been expected from the number of men absent. At many plants inoculation has been general for both office and mill forces. Company physicians have great confidence in the serum used. It may be interesting to note that some steel works physicians insist that autopsies they have witnessed prove that what has been diagnosed as pneumonia accompanying Spanish influenza is something altogether different, the lungs being attacked by ulcers, and not by the formation of fibrine in the blood, as in true pneumonia.

War Requirements

Practically coincident with the German peace drive, there has been an increased demand for steel in France, both from our Allies and from General Pershing direct. The rate of advance of the Allied arms, it appears, measures the volume of many classes of steel required, particularly railroad material. While the consumption of shells does not appear from news despatches at the front to be particularly large at this time, there is pressure for more shell steel, and this despite the fact that the forge shops appear to have run somewhat ahead of the machining operations.

New practices are being introduced as to the distribution of steel to shipyards, the object being to insure a larger supply of the descriptions of steel most needed by certain yards without increasing the total production of ship steel. All comparisons that can be made from information generally available indicate that much more steel has been shipped for account of shipbuilding than has actually appeared in hulls. A reservoir of steel between mills and shipways is very desirable, but the steel needs to be properly spread, an excess of steel at one yard being of no help to another yard that may be short.

The oil pipe line across Scotland, news of which became public through an interview of Franklin D. Roosevelt, assistant secretary of the Navy, was laid with pipe furnished by American mills several months ago, though there was no publication of the matter at the time. The order involved about 60 miles of 8-inch pipe, about 4000 net tons. The object of the line is to make it unnecessary for oil tankers to make the long and somewhat dangerous trip around Scotland. A much larger project is the 300-mile oil line of 12-inch pipe in Texas, orders for which have just been distributed to mills after a lengthy consideration of the subject. About 40,000 net tons is involved. The leading interest was allotted 175 miles, the remaining 125 miles being distributed to several independents.

Distribution Regulations

Important rulings have been made as to "reflected priority," a matter that had been differently interpreted in various quarters in the trade. The regulations providing "automatic priority" were promulgated late in July, under date of July 1. Orders for various named purposes are given their respective grades of priority. Material for building vessels for the Fleet Corporation, for instance, is given A-5 priority. The shipyards, therefore, can attach A-5 priority to the orders they give for material. The question was whether those from whom they bought could in turn attach A-5 priority to the orders they gave, for material to be used in filling the shipyard's orders, and through how many links such a chain could extend. The general ruling is now made "priority can be reflected but once," whereas previously the view had been entertained and followed in some quarters that priority could continue through several links. For a concrete illustration, under former practice a rod mill might recognize as A-5 priority the order of a rivet maker engaged in supplying a shipyard, whereas under the new regulations the rivet maker cannot secure automatic priority for his rods, but must apply for an individual priority. Fears are entertained that so many priority orders will now have to be secured as to delay their issuance, also that the mills will receive many small orders, instead of a few large orders, for rods, merchant mill products, etc., and have difficulty in making up convenient rolling schedules.

After long consideration of the subject of limiting the production of the smaller sizes of standard steel pipe, the War Industries Board has decided to curtail the output of butt weld pipe as a class, and has indicated to each pipe mill the tonnage of steel that can be used for butt weld pipe during November and December. The trade estimates that the regulation will reduce the output of butt weld pipe by about 30 per cent. Under normal conditions standard steel pipe is made from 3-inch downward in butt weld, while 2, 2½ and 3-inch sizes in oil country goods are made by the lap weld process. A part or all of the steel thus saved will pass into oil country goods, stimulating their production, this being one of the objects sought by the new regulation.

The various agreements that have been made from time to time in the past few weeks between the Food Administration and the packers of nonperishable food products in tin cans, whereby certain sizes of packages have been eliminated and the packing of certain products has been curtailed, have been arranged into one comprehensive schedule and distributed to the tin plate mills. Up to date the manufacture of tin plate has been confined to the filling of Government orders and the supplying of tin plate to packers of food products. Indications are that arrangements will be made with a number of packers of products other than food whereby they will limit their operations and will thereupon be allowed to buy and use tin plate. By the order of September 6 the tin plate mills were required to operate during the last three months of the year at not over 70 per cent. of their rate in the last quarter of 1917, but under the regulations as to tin plate consumption the permitted consumption fell far short of absorbing a 70 per cent. production. The prospect now is that enough consumption will be permitted to furnish a market for nearly a 70 per cent. output.

The Chemical Market

Coal Tar Products:—The position of most intermediates has undergone no material change; during the interval, however, in view of the fact that only a few of the items were subject to a pressing demand, stocks on the whole have not accumulated to such an extent that a surplus is on hand. This condition is due mainly to the toluol situation, which is no easier, and other normal causes that are prevailing. The demand for benzol has been sufficient to take the stock off the market, that has been in evidence for some time, and among the more important crudes, phenol is still in pronounced demand, both in the local market and for export purposes. Paranitraniline has evolved to an easier position in the market, and para amidophenol is noticeably scarce, both the base and hydrochloride products.

Phenol:—The market rules very firm and a decided pressing demand has developed in the local market, though interest in the product for export purposes is still very pronounced. However trading in this direction is considerably curtailed through the difficulty in obtaining export licenses. Prices are subject to no material change, for either that which has been manufactured prior to August 20, or the more recent product.

Benzol:—The lack of buying interest that has been prevailing for some time in this market is no longer in evidence, and while trading is of no important volume, there is sufficient business passing at present to take the slack off the market. For material in tank cars, prices are subject to no change while in certain directions a fractional increase was noticed for material in drums.

Dinitrochlorbenzol:—Quotations generally received would indicate the position of this item is very firm. Stocks, however, are by no means liberal, though they are of sufficient quantity to take care of the current demand.

Monochlorbenzol:—The item is one of the intermediates which is more or less neglected, and cheap offerings fre-

quently appear on the market. Large factors, however, are not disposed to shade prices to force business.

Benzidine:—There is no pronounced volume of business reported in the local market and the most noticeable buying interest is for export purposes. The base material and the sulphate are subject to no change in prices, throughout the market.

Para Amidophenol:—A number of factors in this line state they are sold up until the latter part of November. However, fair quantities of the material are available for immediate shipment in spite of the persistent demand for both the base and H. C. L. products. Prices in most directions have been advanced from 25c. to 50c.

Paranitraniline:—The stringent situation that has confronted the consuming trade for some time appears to be easing up, though stocks are not reported in liberal supply. During the past week some cheap offerings appeared on the market, and in a few directions prices have declined from 5c. to 10c.

Paranitrotoluol:—Users of this product at the moment are seemingly experiencing some difficulty in supplying their wants, owing to the fact that most manufacturers are in a sold up condition, and offerings of the material that appear in the resale market are sold at rather high prices.

Benzoate of Soda:—A peculiar situation continues to exist in this market; talk is rather bullish from most directions and the active trading in the item appears to be mainly between dealers, as there is apparently no pressure on the part of consumers in the market. Therefore it is difficult to actually determine the market situation of either the acid or the soda. A variation of prices is heard, with weak holders appearing frequently and playing havoc with the market.

Aniline Oil:—Some factors are completely sold up for a period, but from certain sources available stocks are fully in accordance with the consumption requirements. There is a very steady demand reported, but prices are quotably unchanged.

H. Acid:—Production is centered to a few hands, who report that they are all sold and the small lots that appear in the resale market seem to originate considerable interest. Manufacturers are apparently reticent about quoting on material for early future shipment. Quotations generally heard are virtually nominal, in the absence of real business.

Saccharines:—There are now many conflicting rumors with regard to the general situation of this market, but as near as it is possible to determine the condition, it is generally conceded in most quarters that its entire position is weakening from day to day. Sales that were consummated are closed at some low levels and offerings of the product are made at prices said to be very low.

Dinitrophenol:—Inquiry for this item has been very good, but material for immediate delivery is said to be scarce and quite difficult to locate, in the open market. Large factors of production are devoting their entire energies for government requirement and therefore there is no encouragement offered for civilian consumption. Offerings of the material, on contract, are subject to no change.

Diethylaniline:—The production of this material is not in such quantities so as to accumulate a surplus in stocks. While trading is not very strong, the volume of business passing is sufficient to keep the market scarce of spot material. Prices are quotably unchanged and remain at firm levels.

HEAVY CHEMICALS:—The prevailing conditions, such as peace talk, Spanish influenza and liberty loan drives, have apparently been the factors for the continued lull in the market during the past two weeks. Citric acid, which under normal conditions, is seldom of any particular interest, has developed the feature of the market during the week. Soda ash maintains a firm position and under the lack of interest that has continued for some time; in caustic soda some of the more important factors are closely observing the market, but feel that a weakening position is likely to develop. Calcium carbide is subject to a heavy call and sodium sulphide is in firm demand. There developed a fair call for silicate of soda, but stocks of both the latter items are reported to be meager.

Soda Ash:—Dense material in the various packing is none too liberal in supply, though a strong demand is noted for western shipment. The position of the light product in barrels appears to be somewhat easier and offerings of single bags are in fairly good quantities. Trading during the past week was rather inactive and among the more important sales noted was several cars of single bag material at $2.65 ex-warehouse and sales were consummated for barrel material $3.20 ex-warehouse. Offerings at the close were somewhat easier and single bags were quoted at $2.65 to $2.70 ex-warehouse and ex-dock and in Painsville material was held at $2.70 with some middle west shipments quoted at $2.60. The double bag situation was more restricted in offerings and lots which appeared on the market were held at $3.25 works. Barrel material was available in New York at $3.20 and in Chicago quotations ranged from $3.05 to $3.10, while in St. Louis the same quotation was heard.

Bleaching Powder:—A very serious situation is confronting the consuming trade at the moment and quantities of this material are becoming more and more difficult to obtain. Some factors are quoting 6½c. and buyers of fresh goods are seemingly obliged to meet these prices to supply their pressing needs.

Caustic Soda:—The situation of this market is causing considerable comment and in spite of the unusually quiet conditions that have been prevailing, stocks were none too free and the undertone was rather firm up to the latter part of the week when shipments were in excess of the purchasing, and from all appearances the market has seemingly developed a somewhat weaker position. Prices at the close show a downward tendency from $4.45 to $4.40 ex-warehouse and from works quotations generally went from $4.40 to $4.35. The ground product maintained a firmer position with quotations from the more important factors, ranging from $5.25 to $5.50 ex-warehouse.

Oxalic Acid:—No unusual activity is noted at the moment, in this market. However trading is steady through routine channels and supplies are reported to be fully in accordance with the consuming requirements. Prices remain at the former firm levels ranging from 40c. to 45c. according to seller.

Citric Acid:—There is no question that this item featured the market with a steady and persistent demand throughout the week, due, it is reported, to the extensive use of the product in the present prevailing epidemic. The steady buying pressure has depleted stocks to a very noticeable extent, and prices therefore have advanced from 85c. to $1.06 at the close, with buyers unable to cover at the latter figure in many instances.

Magnesia Calcined:—The light technical product is reported to be in rather scant supply and quotations from several directions are virtually nominal in the absence of firm offerings. However, where small lots of this particular grade are available, prices have been advanced from 70c. to 75c.

Calcium Carbide:—A very firm market is prevailing for this item, but spot stocks are in very limited quantities; lots which appear on the resale market are seemingly the only material available. Producers are not offering owing to their sold up condition and there is no encouragement offered when the situation of the product may be somewhat easier. There is a variation of prices prevailing, ranging from 17c. to 19½c. per pound, in drums crated for export.

Bicarbonate of Soda:—Prices are steadily soaring for this product which is apparently becoming more scarce from day to day. Occasional lots which appear on the market seemingly create considerable interest, and at the close sales were consummated at from 3½c. to 4c. per pound, which is regarded a high mark for the product.

Bichromate of Soda:—The position of this item in the market is gradually weakening and prices are steadily declining, fractionally, from day to day. Quotations at the latter end of the week ranged from 21½c. to 22c. per pound, though in some directions sales were made as low as 21c.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET OCT. 22, 1918

Acetic anhydride	lb.	1.60 —	1.85
Acetone	lb.	.25½ —	.25¾
Acid, acetic, 28 per cent	cwt.	5.96 —	6.11
Acetic, 56 per cent	cwt.	10.76 —	10.87
Acetic, glacial, 99½ per cent., carboys	cwt.	19.00 —	19.20
Boric, crystals	lb.	.13½ —	.15
Citric, crystals	lb.	.82 —	....
Hydrochloric, C. P	lb.	Nominal	
Hydrofluoric, 30 per cent, in barrels	lb.	.08 —	.08½
Lactic, 44 per cent	lb.	.15 —	.16
Lactic, 22 per cent	lb.	.06 —	.07
Molybdic, C. P	lb.	6.90 —	7.40
Nitric, 36 deg	lb.	Nominal	
Nitric, 42 deg	lb.	.08½ —	.10
Oxalic, crystals	lb.	.42 —	.44
Phosphoric, 47-50 per cent paste	lb.	.07½ —	.10
Phosphoric, ref. 50 per cent	lb.	.35 —	.40
Picric	lb.	.75 —	.85
Pyrogallic, resublimed	lb.	3.25 —	3.50
Sulphuric, 60 deg	ton	16.00 —	....
Sulphuric, 66 deg	ton	25.00 —	....
Sulphuric, oleum (Fuming), tank cars	ton	60.00 —	65.00
Tannic, U. S. P., bulk	lb.	1.40 —	1.50
Tartaric, crystals	lb.	.86 —	.95
Tungstic, per lb. of W	lb.	1.70 —	1.75
Alcohol, sugar cane, 188 proof	gal.	4.91 —	....
Alcohol, wood, 95 per cent	gal.	.91½ —	.92
Alcohol, denatured, 180 proof	gal.	.68 —	.69
Alum, ammonia lump	lb.	.06 —	.06½
Alum, chrome ammonium	lb.	.18 —	.19
Alum, chrome potassium	lb.	.20 —	.22
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09½ —	.10
Aluminium sulphate, technical	lb.	.02 —	.02½
Aluminium sulphate, iron free	lb.	.03½ —	.04
Ammonia aqua, 26 deg., carboys	lb.	.08½ —	.09
Ammonia, anhydrous	lb.	Nominal	
Ammonium carbonate	lb.	.12 —	.13
Ammonium nitrate	lb.	(Fixed Price)	.15
Ammonium, sulphate domestic	lb.	.07¾	.08
Amyl acetate	gal.	5.30 —	5.35
Arsenic, white	lb.	.09½ —	.13
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	70.00 —	80.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.04½ —	.05
Barium nitrate	lb.	.12 —	.14
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.06 —	.06½
Borax, crystals, sacks	lb.	.08½ —	.08¾
Brimatone, crude	ton	65.00 —	70.00
Bromine, technical	lb.	.75 —	....
Calcium, acetate, crude	lb.	.04 —	.05
Calcium, carbide	lb.	.17½ —	.19½
Calcium chloride, 70-75 per cent, fused, lump	ton	22.00 —	24.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phosphate	lb.	.22 —	.23
Calcium sulphate, 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.08 —	.09
Carbon tetrachloride, drums	lb.	.60 —	.70
Carbonyl chloride (phosgene)	lb.	1.10 —	1.50
Caustic potash, 88-92 per cent	lb.	.67 —	.72
Caustic soda, 76 per cent	100 lb.	4.40 —	4.45
Chlorine, liquid (Government Purchase)	lb.	(Fixed Price)	.07½
Cobalt oxide	lb.	1.60 —	1.65
Copperas	lb.	.02½ —	.02½
Copper carbonate	lb.	.30 —	.31
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09½ —	.09½
Cream of tartar, crystals	lb.	.75 —	.85
Epsom salt, bags, U.S.P	100 lb.	3.62½ —	3.90
Formaldehyde, 40 per cent	lb.	.16½ —	....
Glauber's salt	lb.	.02½ —	.03
Glycerine, bulk, C. P	lb.	.63 —	.65
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide	lb.	.13 —	.15
Lead acetate, white crystals	lb.	.17 —	.17½
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate	lb.	Nominal	
Litharge, American	lb.	.12 —	.14
Lithium carbonate	lb.	1.50 —	2.05
Magnesium carbonate, technical	lb.	.16 —	.17
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.13
Phosgene (see Carbonyl chloride)	lb.	1.10 —	1.50
Phosphorus, red	lb.	1.00 —	1.15
Phosphorus, yellow	lb.	1.10 —	1.20
Potassium bichromate	lb.	.45 —	.46
Potassium bromide granular	lb.	1.25 —	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38 —	.40
Potassium chlorate, crystals	lb.	.38 —	.40
Potassium cyanide, 98-99 per cent	lb.	.60 —	.70
Potassium iodide	lb.	3.75 —	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	300.00 —	350.00
Potassium nitrate	lb.	.27 —	.31
Potassium permanganate, U. S. P	lb.	1.85 —	2.00
Potassium prussiate, red	lb.	2.30 —	2.50
Potassium prussiate, yellow	lb.	.95 —	1.05
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal	
Rochelle salts	lb.	.47 —	.48
Salammoniac, grav gran	lb.	Nominal	
Salammoniac, white gran	lb.	.22 —	.24
Sal soda	100 lb.	1.40 —	1.65
Salt cake	ton	18.00 —	20.00
Silver cyanide, based on market price of silver	oz.	—	—
Silver nitrate	oz.	.63½ —	.64
Soda ash, 58 per cent, light, flat (bags)	100 lb.	2.65 —	....
Soda ash, 58 per cent, dense, flat	100 lb.	3.75 —	3.80
Sodium acetate	lb.	Nominal	
Sodium bicarbonate, domestic	lb.	.04 —	.04½
Sodium bicarbonate, English	lb.	— —	—
Sodium bichromate	lb.	.21½ —	.22½
Sodium bisulphite, powd	lb.	.12 —	.14
Sodium chlorate	lb.	.25 —	.25½
Sodium cyanide	lb.	.30 —	.35
Sodium fluoride, commercial	lb.	.17 —	.18
Sodium hyposulphite	lb.	2.80 —	3.00
Sodium molybdate, per lb. of Mo	lb.	2.50 —	....
Sodium nitrate, 95 per cent	100 lb.	4.12 —	5.00
Sodium nitrite	lb.	.27 —	.30
Sodium peroxide	lb.	.35 —	.45
Sodium phosphate	lb.	.04 —	.04½
Sodium prussiate, yellow	lb.	.39 —	.40
Sodium silicate, liquid (60 deg.)	lb.	.03 —	.04
Sodium sulphide, 30 per cent, crystals	lb.	.07½ —	.08½
Sodium sulphide, 60 per cent, fused	100 lb.	.10½ —	.11½
Sodium sulphite	lb.	.05½ —	.06
Strontium nitrate	lb.	.25 —	.30
Sulphur chloride, drums	lb.	.07½ —	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4.35 —	4.50
Sulphur, roll	100 lb.	3.70 —	3.85
Sulphur, crude	ton	65.00 —	70.00
Tin bichloride, 50 deg	lb.	.28 —	.29
Tin oxide	lb.	Nominal	
Zinc carbonate	lb.	.18 —	.20
Zinc chloride	lb.	.15 —	.15½
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.13½ —	.14
Zinc oxide, American process XX	lb.	.12½ —	.14
Zinc sulphate	lb.	.04½ —	.06½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22½ —	.27
Benzol, 90 per cent	gal.	.25 —	....
Toluol, in tank cars	gal.	(Fixed Price)	1.50
Toluol, for non-military use, in drums	gal.	(Fixed Price)	1.55
Xylol, pure, water white	gal.	.45 —	.55
Solvent naphtha, water white	gal.	.18 —	.25
Solvent naphtha, crude, heavy	gal.	.12 —	.15
Creosote oil, 25 per cent	gal.	.45 —	.55
Dip oil, 20 per cent	gal.	.30 —	.32
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05 —	1.10
Carbolic acid, crude, 50 per cent	lb.	.60 —	.65
Carbolic acid, crude, 25 per cent	lb.	.35 —	.38
Cresol, U. S. P	lb.	.19 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.50 —	1.60
Alpha naphthylamine	lb.	.55 —	.60
Aniline oil, drums extra	lb.	.30 —	.32
Aniline salts	lb.	.43 —	.45
Anthracene, 80 per cent	lb.	Nominal	
Benzaldehyde (f.f.c.)	lb.	4.25 —	4.50
Benzidine, base	lb.	1.75 —	1.85
Benzidine, sulphate	lb.	1.40 —	1.45
Benzoic acid, U. S. P	lb.	3.00 —	3.10
Benzoate of Soda, U. S. P	lb.	2.90 —	3.00
Benzyl chloride	lb.	2.45 —	2.50
Beta naphthol benzoate	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	.75 —	.85
Beta naphthylamine, sublimed	lb.	2.65 —	....
Dichlor benzol	lb.	.15 —	.20
Diethylaniline	lb.	4.00 —	4.50
Dinitro benzol	lb.	.36 —	.38
Dinitrochlorbenzol	lb.	.40 —	.45
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.65 —	.75
Dinitrophenol	lb.	.55 —	.60
Dimethylaniline	lb.	.74 —	.76
Diphenylamine	lb.	1.00 —	1.10
H-acid	lb.	3.25 —	3.50
Metaphenylenediamine	lb.	1.85 —	2.05
Monochlorbenzol	lb.	.17 —	.20½
Naphthalene, flake	lb.	.09 —	....
Naphthalene, balls	lb.	.11 —	.12½
Naphtionic acid, crude	lb.	1.20 —	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.55 —	.60
Ortho-amidophenol	lb.	6.50 —	7.00
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-toluidine	lb.	1.00 —	1.10
Ortho-nitro-toluol	lb.	.75 —	.85
Para-amidophenol, base	lb.	4.25 —	4.50
Para-amidophenol, H. Ch.	lb.	4.25 —	5.00
Para-dichlor-benzol	lb.	.15 —	.20
Paranitraniline	lb.	1.80 —	1.95
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	4.00 —	4.50
Para toluidine	lb.	2.25 —	2.50
Phthalic acid anhydride	lb.	4.25 —	5.00
Phenol, U. S. P	lb.	.44 —	.47
Resorcin, technical	lb.	4.50 —	5.00
Resorcin, pure	lb.	7.50 —	8.00
Salicylic acid	lb.	.85 —	....
Salol	lb.	1.50 —	2.00
Sulphanilic acid, crude	lb.	.31 —	.33
Toluidine	lb.	2.50 —	3.00
Toluidine-mixture	lb.	.85 —	.90

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00 —	....
Corning, Ohio	bbl.	2.85 —	....
Somerset, Ky	bbl.	2.60 —	....
Wooster, Ohio	bbl.	2.68 —	....
Indiana	bbl.	2.28 —	....
Illinois	bbl.	2.42 —	....
Oklahoma and Kansas	bbl.	2.25 —	....
Caddo, La., light	bbl.	2.25 —	....
Corsicana, Tex., light	bbl.	2.25 —	....
California	bbl.	1.24 —	1.57
Gulf Coast	bbl.	1.35 —	....
Mexican	bbl.	1.90 —	....

Fuel Oil

New York	gal.	.15 —	....
Philadelphia	gal.	.10½ —	....
Baltimore	gal.	.07½ —	.15½
Pittsburgh	gal.	.07½ —	.10
Texas	bbl.	1.85 —	2.35
Los Angeles	bbl.	1.65 —	....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	....
Gas machine	gal.	.41½	—	....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	....
Chicago, motor	gal.	.22½	—	.23
Oklahoma, motor	gal.	.21½	—	....
San Francisco, motor	gal.	.20½	—	....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	....
Refined, 120 deg. m.pt	lb.	.13½	—	....
Refined, 128 deg. m.pt	lb.	.14	—	....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.24	—	.25
Cylinder, light	gal.	.45	—	.50
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr	gal.	.36	—	.38
Paraffine, 0.885 sp. gr	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	....
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.23	—	....
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.23	—	....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	....

Naval Stores

Rosin A-E barrel	280 lb.	15.25	—	15.50
Rosin F-I	280 lb.	15.50	—	16.00
Rosin K-N	280 lb.	16.00	—	16.90
Rosin WG-W	280 lb.	16.90	—	17.25
Spirits of turpentine	gal.	.67	—	....
Wood turpentine, steam distilled	gal.	.63	—	....
Wood turpentine, destructively distilled	gal.	.58	—	....
Pitch	bbl. 200 lb.	7.50	—	....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.80	—	....
Second run	gal.	.83	—	....
Third run	gal.	.88	—	....
Fourth run	gal.	.98	—	....

Vegetable Oils

Castor oil	lb.	.34	—	.38
China wood oil	lb.	.30	—	.31
Cocoanut oil	lb.	.17	—	.22
Corn oil	lb.	.18	—	....
Cottonseed oil, crude	lb.	.20	—	.22
Linseed oil, raw, cars	gal.	1.81	—	1.86
Olive oil	gal.	4.25	—	4.50
Peanut oil, crude	lb.	.18	—	.22
Soya bean oil, Manchuria	lb.	.17	—	.18½

Glues

Extra white	lb.	.36	—	.45
Cabinet	lb.	.31	—	.40
Brown foot stock	lb.	.18	—	.22
Fish glue, 50-gal. barrels	gal.	1.00	—	1.80

Miscellaneous Materials

Barytes, floated, white, foreign	ton	38.00	—	42.00
Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	....
Casein	lb.	.17½	—	.30
Ceylon graphite	lb.	.07½	—	.25
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f.o.b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Japan wax	lb.	.26	—	.27
Mexican graphite	ton	75.00	—	....
Madagascar graphite	lb.	.10	—	.15
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Red lead, dry, carloads	100 lb.	.11½	—	.11½
Soapstone	ton	15.00	—	25.00
Stearic acid, 120 deg. m.pt	lb.	.13	—	.14
Stearic acid, 140 deg. mpt	lb.	.18	—	.19
Talc, American, white	ton	20.00	—	40.00
White lead, dry	lb.	.09½	—	.10½

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	175.00	—	....
Chrome cement	net ton	75.00	—	....
Clay brick, first quality firecla	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	50.00	—	60.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	250.00	—	....
Ferromanganese, English	ton	325.00	—	....
Spiegeleisen (16-18%)	ton	75.00	—	....
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton		—	
Ferrosilicon, 50 per cent, contract	ton	153.00	—	160.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.40
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	....
Ferrovanadium, f.o.b. works	lb.	....	—	....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Chrome ore, 43 per cent and over, New York, per unit	ton	1.40	—	....
Coke	ton	6.00	—	7.00
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.25	—	1.50
Tungsten, Scheelite, per unit of WO_3	ton	25.50	—	....
Tungsten, Wolframite, per unit of WO_3	ton	24.00	—	....
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	....
Pyrites, foreign	unit	.17	—	....
Pyrites, domestic	unit	.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	13.00	—	14.00
Hollow tile, 4 x 12 x 12	M	60.00	—	....
Hollow tile, 12 x 12 x 12	M	170.00	—	....
Lime	ton	16.50	—	....
Portland cement	bbl.	2.59	—	
Single glass (82-lb.), 10 x 26-16 x 24		21.00	—	27.00
Double glass (164 lb.), 10 x 26-16 x 29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Fir lumber	M	38.00	—	53.00
Hemlock	M	24.50	—	40.00
Tarred felt (14-lb.sq.)	ton	68.00	—	....
Roofing pitch	ton	27.00	—	....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1.20	—	1.58
White lead in oil	100 lb.	11.84	—	14.00
Red lead in oil	100 lb.	12.28	—	14.50
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	84.00	—	89.00
Black sheet iron	ton	96.00	—	104.00
Galvanized iron	ton	105.00	—	135.00
Tern plate, 8-lb. coating	ton	150.00	—	....
Tern plate, 15-lb. coating	ton	177.50	—	....
Tern plate, 25-lb. coating	ton	200.00	—	....
Tern plate, 40-lb. coating	ton	240.00	—	....
Tin plate, prime	ton	155.00	—	....
Tank plates	ton	65.00	—	70.00
Beams, channels, angles, T's, Z's	ton	60.00	—	65.00
Rivets	ton	88.00	—	92.00
Steel pipe, ¼ to 3-inch	ton	51.00	—	....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steels, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	36.60	—	....
Bessemer steel	ton	47.50	—	....
No. 2 foundry	ton	37.90	—	....
Steel billets (4 x 4)	ton	47.50	—	....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	....
Asbestos, wired	lb.	1.30	—	....
Asbestos, graphited braid	lb.	1.21	—	....
Asbestos, wick	lb.	.75	—	....
Rubber, sheet	lb.	.66	—	....
Cup grease	lb.	.07	—	....
Transmission grease	lb.	.07	—	....
Axle grease	lb.	.04½	—	....
Gear grease	lb.	.04½	—	....
Cotton waste	lb.	.08½	—	.13
Hose, underwriters, 2½ in	ft.	.75	—	....
Hose, air, ¾ in	ft.	.30	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

ASHLAND—The Dixie Graphite Co., 407 Jefferson Bank Building will build a mill on its graphite property here having a capacity of 200 tons per day. J. R. Malaney, in charge.

BIRMINGHAM—The Welded Products Co., 803 American Trust Building, has awarded the contract for the construction of a 90 x 225 ft. acetylene welding plant to the Smallmen-Brice Construction Co., American Trade Building.

Arkansas

FORT SMITH—The Missouri-Arkansas Oxygen Co., c/o Best-Clymer Manufacturing Co., will install a hydrogen plant in connection with its proposed oxygen plant.

California

GIANT—Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a TNT plant located near the nitric acid plant of the Giant Powder Co., to Grant, Smith & Co., Henry Bldg., Seattle, Wash. Estimated cost, $1,438,000.

MANTECA—The city will build a sewerage system, outfall sewer and disposal plant. Estimated cost, $42,000.

Colorado

SILVER CLIFF—The Buffalo Hunter M. M. & D. Co. will build a concentration, roasting and cyaniding plant at its Mn-Ag open pit mine having a capacity of 400,000 tons per year and is in the market for crushers, Wilfley tables, gas producers, tube mills, Dorr agitators, steam shovels, track, cars, engines, boilers and pipe. Estimated cost, $150,000 Captain L. D. Miller, superintendent.

District of Columbia

WASHINGTON—Bids will be received at the office of the General Purchasing Officer, Panama Canal, until November 13 for furnishing ferro-manganese, carbon bisulphide, calcium chloride, wax, sulphuric acid, ethyl alcohol, pitch, glue, fire clay, graphite, enamel, white zinc, red oxide of mercury, shellac, etc.

Florida

MIAMI—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until Nov. 4 for the construction of a reclaiming building and septic tank. Specification No. 3549. Estimated cost, $20,000.

Illinois

FRANKFORT—The Elgin, Joliet & Eastern Railway Co. has awarded the contract for the construction of a water softening plant here to William Graver, 4809 Todd Ave., Chicago. A. Montzheimer, Joliet, chief engineer.

GREAT LAKES—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., will alter and build additions to its sewage disposal plant. Estimated cost, $13,000.

MOUNT CARMEL—A. Lieberman and Lewis Dumes will build a fertilizer plant near here. Estimated cost, $25,000.

SPAULDING—The Elgin, Joliet & Eastern Railway has awarded the contract for the construction of a water softening plant here, to William Graver, 4809 Todd Ave., Chicago. A. Montzheimer, Joliet, chief engineer.

Iowa

FAIRPORT—The Commissioner of Fisheries, Department of Commerce, Washington, D. C., will build a laboratory building at the biological station here.

Kansas

FORT SCOTT—The city will build dam and filtration plant. Estimated cost, $82,000. Black & Veatch, engineers, Interstate Building, Kansas City, Mo., preparing plans.

GALENA—The City will build a filtration plant. Estimated cost, $100,000. Burns & McDonnell, engineers, Interstate Building, Kansas City, Mo., preparing plans.

Louisiana

NEW ORLEANS—The Jackson Brewing Co. will remodel and convert its building into a plant for de-hydrating vegetables, etc., also the manufacturing of alcohol and syrup.

Maryland

INDIAN HEAD—The Bureau of Yards & Docks, Navy Department, Wash., D. C., will build a laboratory building here. Specification No. 3208. Estimated cost, $20,000.

MONKTON—The Monkton Roller Co., Inc., has awarded the contract for the construction of a roller mills plant, to E. H. Mosher, 427 Munsey Building, Baltimore. Project includes 32 x 72 ft. main mill, 20 x 45 ft. corn mill and hydro electric plant, also equipment for same. Estimated cost, $134,000.

Massachusetts

LEE—The Smith Paper Co. has awarded the contract for the erection of a three-story, 90 x 100 ft. concrete and brick paper mill addition, to the Lynch Brick Construction Co., 206 High St., Holyoke. Estimated cost, $60,000.

WORCESTER—The Wyman-Gordon Co., 105 Madison St., has awarded the contract for the construction of an additional story to its laboratory on Gold St. to E. J. Cross Co., 82 Foster St.

Michigan

DETROIT—The Cummings & Moore Graphite Co., 672 Water St., will build a two-story, 133 x 135 ft. grinding room addition. Stahl & Kinsey, 117 West Fort St., architect, taking bids.

GRAND RAPIDS—The Grand Rapids Brass Co. will build a three story addition to its plant at Scribner Ave. and Shawmut St. Osgood & Osgood, Engrs., preparing plans.

MANISTIQUE—The Manistique Pulp & Paper Co. will build an addition to its plant. Estimated cost, $500,000. H. J. Storer, consulting engineer.

Missouri

CHETTWOOD—Pfaeffle & Kelley have awarded the contract for remodeling their 200-ton plant to Carmody V. McGee, 631 Frisco Building, Joplin, and is in the market for lumber, mill hardware, engine, sludge tables, roofing and air compressors. Estimated cost, $50,000. J. P. Kelley, superintendent.

JOPLIN—The C. H. & M. Mining Co. will remodel and improve its plant and build tramway and is in the market for new scales, sludge tables, lumber, rails, cross ties, wire cables, scales and engine. Estimated cost, $6000. Burt Pitts, superintendent.

ST. LOUIS—The Mallinckrodt Chemical Works, 2nd and Mallinckrodt St., has awarded the contract for the erection of a factory at 100 Salisbury St. for the manufacture of chemicals to the A. H. Haeseler Building & Contracting Co., Wainwright Bldg. Estimated cost, $6000.

ST. LOUIS—The Pan Electric Manufacturing Co., 735 South 4th St., will build laboratories in connection with its proposed two-story, 40 x 50 ft. concrete and brick office building at 4090 Bingham St. Estimated cost, $10,000. G. P. West, Wainwright Building, architect.

WEBB CITY—The Brown-Head Mining Co., Miami, Okla., will rebuild the 500-ton mill it recently purchased. A. Rowe, general manager.

New Jersey

CLAREMONT—The Standard Oil Co., 26 Broadway, New York City, N. Y., has awarded the contract for the construction of a tank house and a filter house here to James Stewart & Co., Church St., New York City, N. Y.

ELIZABETHPORT—The Borne-Scrymser Co. has awarded the contract for the construction of a two story, 30 x 50 ft. concrete chemical laboratory, also a four story, 42 x 62 ft. addition to its grease house to H. D. Best Co., Flatiron Building, New York City, N. Y.

JERSEY CITY—The Baker Castor Oil Co., Washington St., will build a reinforced-concrete addition to its plant. Estimated cost, $75,000.

NEWARK—The Oxweld Acetylene Co., 640 Frelinghuysen Ave., will build a three story, 42 x 100 ft. addition to its plant. Estimated cost, $50,000.

TRENTON—The School of Industrial Arts, West State and Willow St., will build an automobile engine laboratory in connection with the proposed two story, 56 x 65 ft. school on Quarry St. Frank Frederick, director.

New York

ALBANY—The Patent Vulcanite Roofing Co., Tivoli St., has awarded the contract for the erection of a one story, 72 x 245 ft. concrete and brick factory to the Hamill Construction Co., Gay Bldg., Troy. Estimated cost, $30,000. Noted Oct. 15.

BINGHAMTON—The Binghamton State Hospital will build an addition to its analytical laboratory. L. F. Pilcher, Capitol, Albany, architect.

BROOKLYN—The New York Quinine & Chemical Co., 99 11th St., will build a 50 x 100 ft. concrete and brick addition to its factory on Berry St. Estimated cost, $25,000. T. Englehardt, 905 Broadway, architect.

LONG ISLAND (Laurel Hill)—The General Chemical Co., 25 Broad St., New York City, has awarded the contract for the erection of a two story, 40 x 116 ft. concrete and brick factory at Hall St. and Washington Ave., Laurel Hill, to Leddy & Moore, 105 West 40th St., New York City. Estimated cost, $35,000.

TONAWANDA—The Acheson Graphite Co., Buffalo Ave., Niagara Falls, has awarded the contract for the construction of a new plant to the J. W. Cowper Co., Fidelity Building, Buffalo. Estimated cost, $15,000.

North Carolina

ROSMAN—The Toxaway Tanning Co. will reconstruct its mill recently destroyed by fire; new machinery will be installed in same.

WILMINGTON—The city will improve its water-works to include a reinforced-concrete sedimentation basin having a capacity of 1,500,000 gallons, a 5,000,000 gallon centrifugal steam driven pump and four 12 x 15 ft. additional filter units, etc. J. Newton Johnson, city engineer, preparing plans.

Ohio

AKRON—The Quick Rubber Co., Home Ave., will build a factory. Estimated cost, $25,000. G. W. Reid, general manager.

CLEVELAND—The Cleveland Brass & Copper Mills Co., 322 Guardian Building, has awarded the contract for the construction of a one story, 77 x 130 ft. concrete, brick and steel factory on Babbitt Rd., to Craig Curtiss Co., Guardian Building. Estimated cost, $50,000.

LORAIN—The Cleveland Salt Co., 5912 Central Ave., Cleveland, will build a chemical plant here, consisting of six buildings, one and two stories high. L. G. Findlay, 503 Union Building, Cleveland, engineer.

NORWOOD—The city plans an election on November 5 to vote on a $50,000 bond issue for the construction of a water softening system. Allen Kissenger, city engineer.

PARMA (Cleveland P. O.)—The Swift & Co., 3240 West 65th St., will build a two story, 50 x 75 ft. concrete, brick and steel fertilizer factory. Estimated cost, $25,000.

Oklahoma

CENTURY—The Federal Lead and Zinc Mining Co. will build new incline hoister skids and remodel its 400-ton concentration plant; it is in the market for lumber, cross ties, concrete, sludge table, jigs, ore cans, ore cars, hoister, wiring, cables, belts, engine, pipe, roofing and track. Estimated cost, $35,000. W. M. Martin, superintendent.

GROVE—W. T. Croslin and George F. Clark will build a kaolin plant and is in the market for engine, boiler, lumber, concrete, hardware, china making machinery, kiln, dryers, track, cars, belts, pumps and roofing. Estimated cost, $25,000.

STILLWATER—The city will build a filter plant, boiler room, engine room, etc.; filtering equipment having a capacity of 690,000 gallons per hour will be installed in same. J. L. Moore, city clerk.

Oregon

BEAGLE—The Rainier Quicksilver Co. will enlarge its plant and is in the market for furnace equipment for same. Estimated cost, $5000. Samuel Bertleson, superintendent.

Pennsylvania

CLOYLAND—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a toxic gas plant to the Cleveland Construction Co., 1028 Citizens Building, Cleveland, Ohio. Estimated cost, $2,000,000.

EMPORIUM—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of eight units for the manufacture of explosives, located near the plant of the Aetna Explosive Co., to the Leonard Construction Co., 332 South Michigan Ave., Chicago, Ill. Estimated cost, $2,000,000.

HEIDELBURG—The Aetna Chemical Co. will rebuild its fusion building recently destroyed by fire.

MOUNT UNION—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a plant here for the manufacture of explosives to the Leonard Construction Co., 332 South Michigan Ave., Chicago, Ill. Estimated cost, $1,000,000.

PHILADELPHIA—Powers, Weightman & Rosengarten, 916 Parrish St., has awarded the contract for the construction of a factory for the manufacture of chemicals to R. C. Ballinger, 17th and Arch St. Estimated cost, $6000. Noted June 15.

PHILADELPHIA—The Tioga Steel & Iron Co., 52nd St. and Gray's Ave., will build a 24 x 60 ft. water softening plant for its gun plant here.

Rhode Island

EAST PROVIDENCE—The Rumford Chemical Works, 231 South Main St., has awarded the contract for the construction of a 1-story, 50 x 252 ft. addition to its plant to William Merchant, Inc., 186 Weybosset St. Estimated cost, $18,000.

South Dakota

PLATTE—C. F. Slate, city auditor, will receive bids until November 4 for the construction of a sewerage system and sewage disposal plant involving approximately 6100 lin.ft. of 15 in.; 1100 lin.ft. 12 in.; 1465 lin.ft. 10 in. and 26,075 lin.ft. 8 in. sewer, together with necessary appurtenances, septic tank, sludge bed and sand filter bed.

Tennessee

MEMPHIS—The Memphis Gas & Electric Co. has awarded the contract for the construction of two concrete buildings and scrubber house and the installation of 27 ovens to Phillips Lang Co., 343 Dearborn St.

Texas

AUSTIN—The city will receive bids until Oct. 31 for the construction of sewage disposal plant. A. P. Woolridge, mayor.

HONEY GROVE—The city will build a hypochlorite disinfecting plant. Address the Mayor.

Virginia

NORFOLK—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build a galvanizing plant, oxyacetylene and generating plant here; Specification No. 3383. Estimated cost, $110,000.

OAK—The Virginia Mari Co., Box 1594, Richmond, is in the market for complete equipment for a lime and fertilizer plant.

PORTSMOUTH—The City Gas Co. and the United States Housing Corporation will build a gas plant to furnish sufficient gas to the Government settlement at Paradise Creek and Villa Heights; plans include the installation of machinery, laying of pipe, etc. Total estimated cost, $175,000 to $200,000.

RICHMOND—The Air Reduction Co., 120 Broadway, New York City, N. Y., has awarded the contract for the construction of a 60 x 102 ft. concrete chemical plant for the manufacture of oxygen, nitrogen and acetylene gases, to the James Mitchell, Inc., 76 Montgomery St., Jersey City, N. J. Estimated cost, $80,000.

Washington

TACOMA—The Skinner & Eddy Corporation, 1599 Railroad Ave., S., will build a large electric smelter here. Estimated cost, $750,000.

VANCOUVER—The Rand Iron Works, 608 Ingalls St., will build a furnace room. Estimated cost, $6000.

West Virginia

BELLE—The Charleston Chemical Plant will rebuild its factory destroyed by fire, entailing a loss of $400,000.

British Columbia

GRAVES POINT—The Granby Consolidated Mining, Smelting & Power Co., 718 Granville St., Vancouver, will build a by-products plant here. Estimated cost, $1,250,000.

POWELL RIVER—The Powell River Pulp & Paper Co. will rebuild its mill recently destroyed by fire.

Ontario

HASTINGS—The Hastings Tanning Co. will build a one and two story, 200 x 200 and 40 x 90 ft. tannery. Estimated cost, $50,000. B. E. Parks & Sons, Grand Rapids Savings Bank, Grand Rapids, Mich., architect.

KIRKLAND LAKE—The Wright-Hargrave Gold Mines will build a mill and cyanide plant to have a capacity of 45,000 tons per year. Estimated cost, $150,000. A. Wendy, superintendent.

LONDON—The City Council will build a low level intercepter and sewage pumping plant, also sewage disposal works. Estimated cost, $300,000. H. A. Brazier, engineer.

TORONTO—The Galena Signal Oil Co., 134 Royce Ave., has awarded the contract for the construction of a concrete oil plant to the Toms Contracting Co., Kent Building. Estimated cost, $60,000.

Industrial Notes

THE NATIONAL ANILINE & CHEMICAL COMPANY, INC., 21 Burling Slip, New York, announce the appointment of Mr. W. W. Jones as the manager of the essential oil and gum department. He was formerly manager of the New York office of Frederick Stearns & Company.

THE CHEMICAL EXPOSITION COMPANY wish to announce that they will be located hereafter at 405 Lexington Ave., New York City, instead of the Grand Central Palace, which has been taken over by the Government.

THE UNITED ALLOY STEEL CORPORATION, Canton, Ohio, will open a sales office at 614 Swetland Building, Cleveland, which will be in charge of I. J. Shults.

THE ZIRCONIUM SYNDICATE, LTD. of Great Britain, are now manufacturing white zirconium, practically pure. It is believed that the production of zirconia on a substantial scale and at a commercial figure has never been accomplished before outside of Germany.

THE NEW JERSEY ZINC COMPANY have issued a new set of books entitled "Pigments," "Metals," "Roller Zinc" and "Zinc Dust" which they call a "Handy Reference Library of Zinc Products." Each booklet briefly describes certain zinc products giving information that the average person might like to know.

THE INDUSTRIAL ELECTRIC FURNACE CO., Chicago, makers of the Snyder Electric Furnace, are installing a five ton furnace in the plant of the Zimmerman Steel Company, Bettendorf, Iowa. It is a three-phase furnace, designed for acid operation, and will be used for general work. C. H. Atherton, manager of the Zimmerman Steel Company, ordered the installation to replace the converter which they had been using.

THE ELECTRO BLEACHING GAS COMPANY has suffered so many losses in its technical forces due to the demands for war purposes that it has been necessary to discontinue the Chicago office. Mr. G. R. Ellis, who has been in charge of the Chicago territory has been transferred to the Niagara Falls plant and placed in charge of the office work.

THE PERSOL CHEMICAL CORPORATION has just bought a large manufacturing plant in Buffalo, N. Y., and will commence operations Nov. 1, 1918. Their specialty will be electrochemical products.

THE AMERICAN NITROGEN PRODUCTS COMPANY announce the opening of Eastern offices in the Woolworth Building, New York City, where the usual business courtesies will be gladly extended.

MR. R. D. KEHOE announces that he has disposed of his interest in the Machinery Utilities Company, Inc., and severed all connections therewith. He also announces the formation of the Technical Products Company, Inc., with offices in New York, Chicago and St. Louis, for the purpose of covering special fields of work not hitherto taken up by the Machinery Utilities Company and on a broader scale. The new organization will maintain a staff of technical men for the purpose of purchasing inactive equipment and placing it in essential industries. The new organization will not compete with the Machinery Utilities Company, Inc., but will enter other fields of work.

THE WHITLOCK COIL PIPE COMPANY, Hartford, Conn., announces the opening of a Boston office at 50 Congress Street, under the management of MR. W. B. HOYT, who was the former Rochester representative.

THE PALO COMPANY, 90 Maiden Lane, New York City, have taken over the plant of Otto P. Weisswange of Mt. Vernon, N. Y., manufacturing precision instruments, thermometers and glassware to meet the requirements of the Bureau of Standards. This plant was bought mainly to fill Government orders.

THE CELLULOSE CO., New York City, which is financed by Vickers Co. and Nobel Co., London, will commence building the $10,000,000 Cumberland, Md., cellulose manufacturing plant recently announced by the War Department. For the duration of the war the cellulose products will be taken by the Government for airplanes; after that the company intends manufacturing acids, drugs, dyes, etc., from cellulose and other materials.

THE BON AIR COAL AND IRON CORPORATION, of Nashville, is building a wood chemical plant at Lyles, Tenn., in accordance with contract to supply the Government with materials for explosives manufacturing. The plant will be in operation about Dec. 1. This factory expects to produce from 2000 to 3000 gallons of wood alcohol, 40,000 pounds of acetate of lime, and 10,000 bushels of charcoal per day. The Government will take all the alcohol and acetate of lime for the purpose of manufacturing explosives, the output of charcoal will be burned in the Bon Air Coal and Iron Company's iron furnace.

RICKETTS & COMPANY, INC., mining, metallurgical and chemical engineers, have opened new laboratories at Room 509, 80 Maiden Lane, New York City. They are now equipped for assay and analytical work of all kinds, especially analyses of glycerin and manganese.

MESSRS. A. E. S. THOMPSON & COMPANY, handling large quantities of chemicals and dyes in the Oriental market, has established a branch in the Merchants Exchange Building, San Francisco.

THE INTERNATIONAL OXYGEN COMPANY recently sent Mr. George Quelch, one of the staff engineers, to England to supervise the installation of a 400-cell plant of I. C. C. Unit oxyhydrogen generators for the British Admiralty. Mr. Phillips Wesley has been appointed manager in charge of the oxyhydrogen plant and sales office of the company at Pittsburgh, and Mr. Jack Heller has joined its New York sales force, succeeding Mr. Barnitz.

Manufacturers' Catalogs

THE CHEMICAL CONSTRUCTION COMPANY, Charlotte, N. C., has published an attractive pamphlet descriptive of its service in the design and construction of acid plants. Considerable space is devoted to a description of a chemical concentrator for the concentration of sulphur and phosphoric acids.

THE INTERNATIONAL OXYGEN COMPANY, 115 Broadway, New York City, calls attention to its new publication entitled "I. O. C. 4-1000 Unit Generators for Oxygen and Hydrogen" which is catalog No. 4. This 24-page catalog describes and illustrates the latest improved electrolytic oxyhydrogen generator of the company, gives dimensions and capacities, and presents working plans of two typical plant layouts of common capacity showing the extreme compactness of this new cell.